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(54) **MULTIPLE SUTURE THREAD CONFIGURATION WITH AN INTERMEDIATE CONNECTOR**

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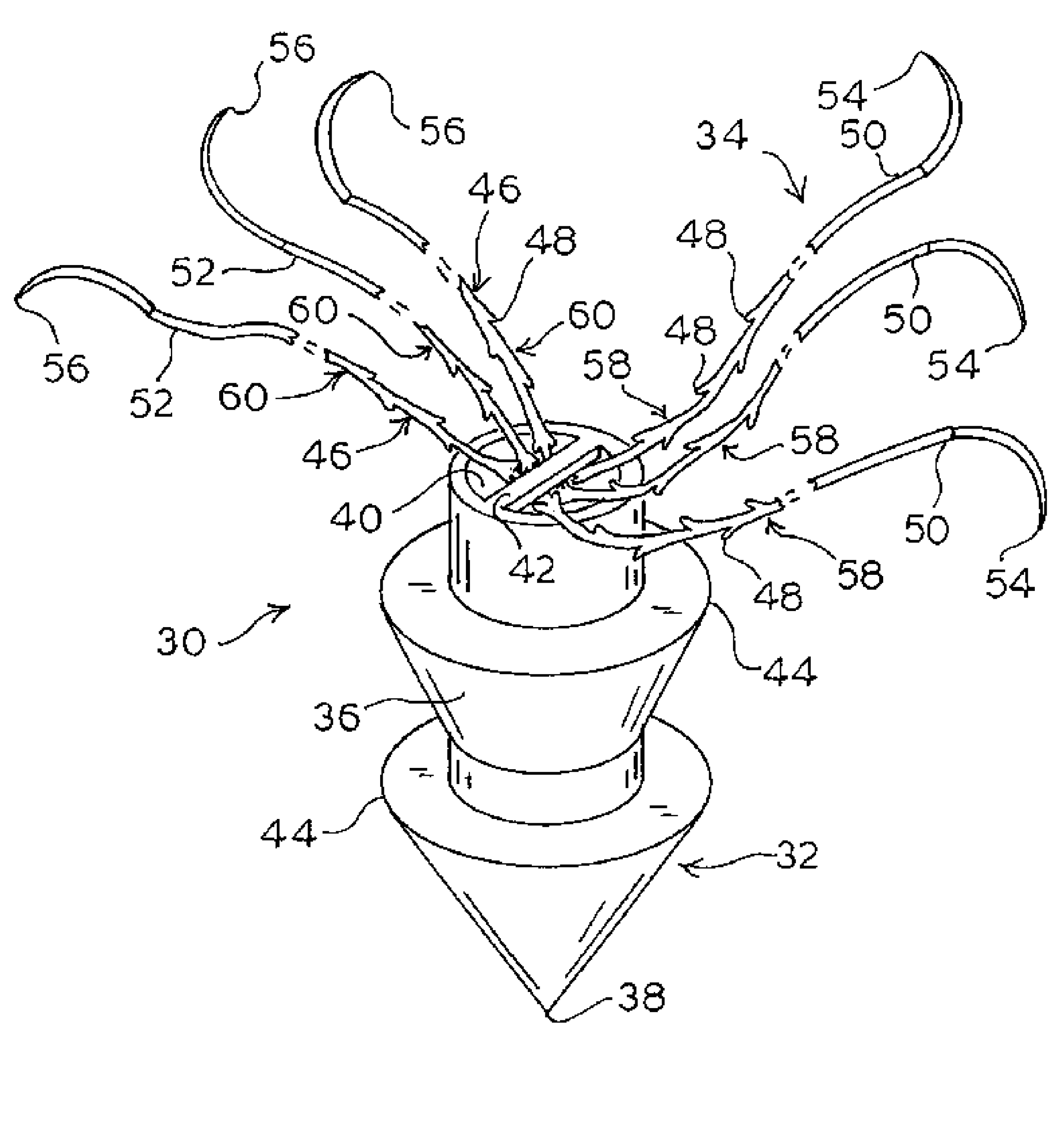
(57) **ABSTRACT**

A suture system has a plurality of barbed sutures each with a plurality of barbs and a body connector that connects said plurality of barbed sutures. The sutures can move relative to the body connector. The body connector can retain tissue.

12 Claims, 11 Drawing Sheets



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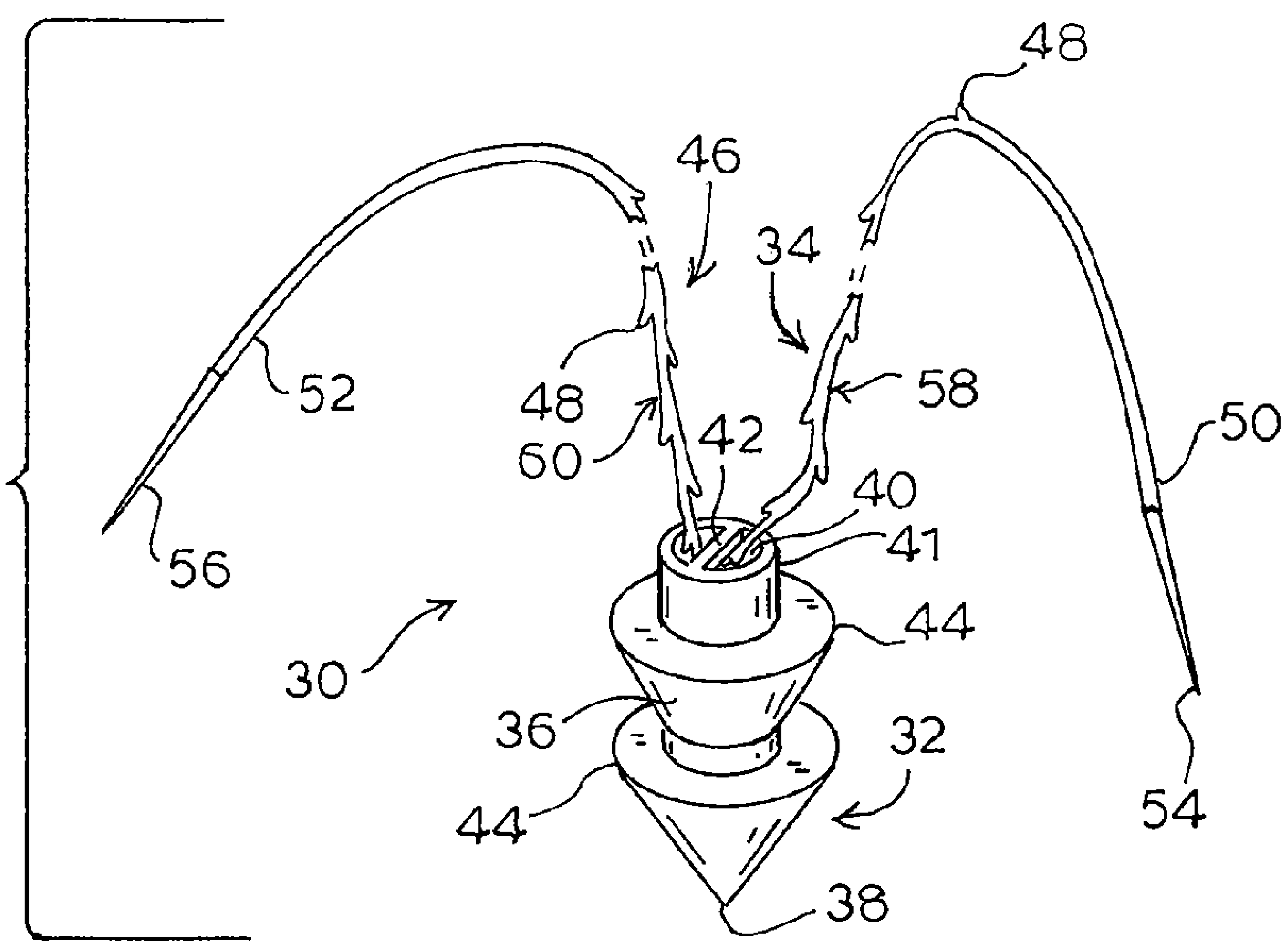
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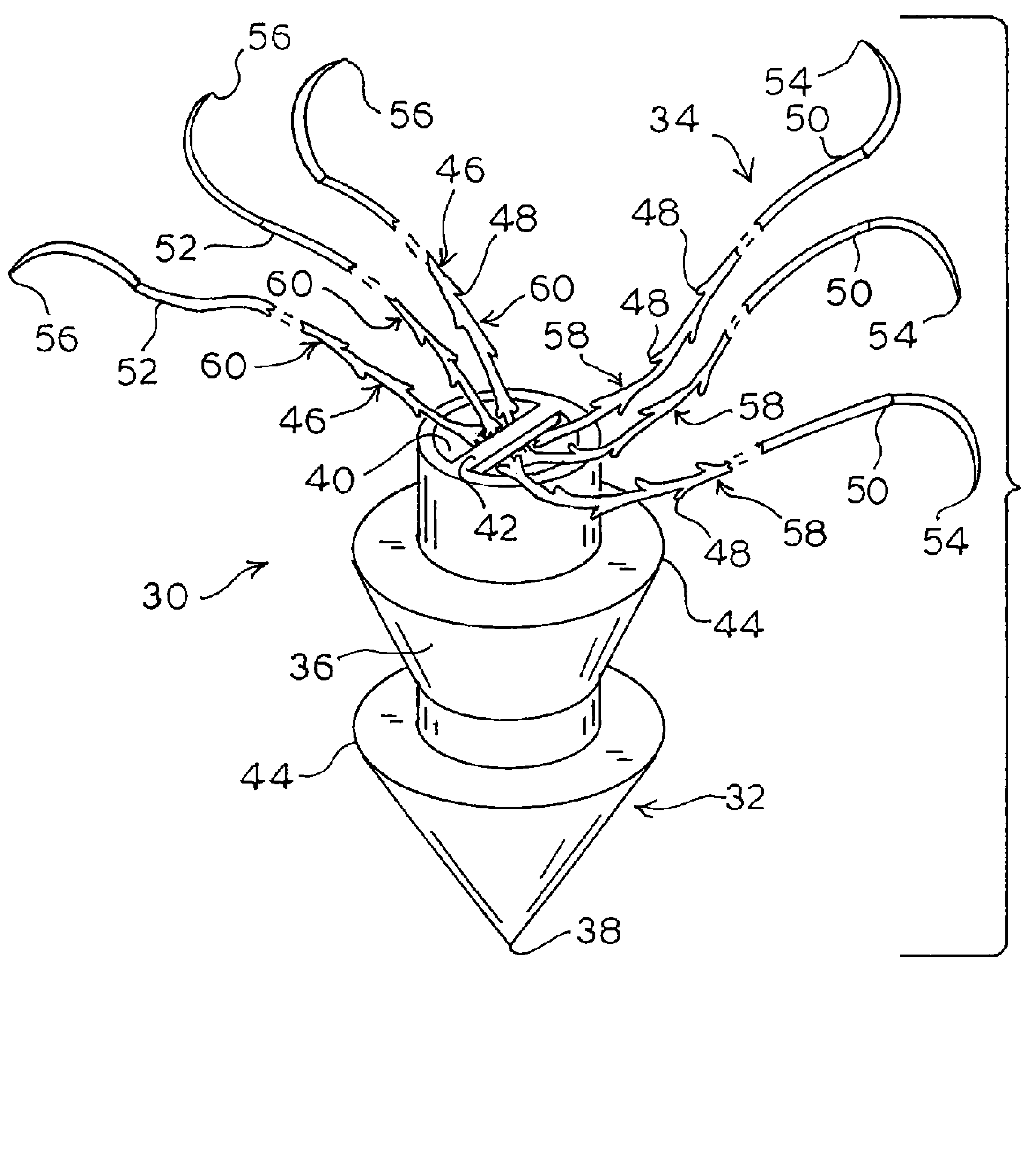
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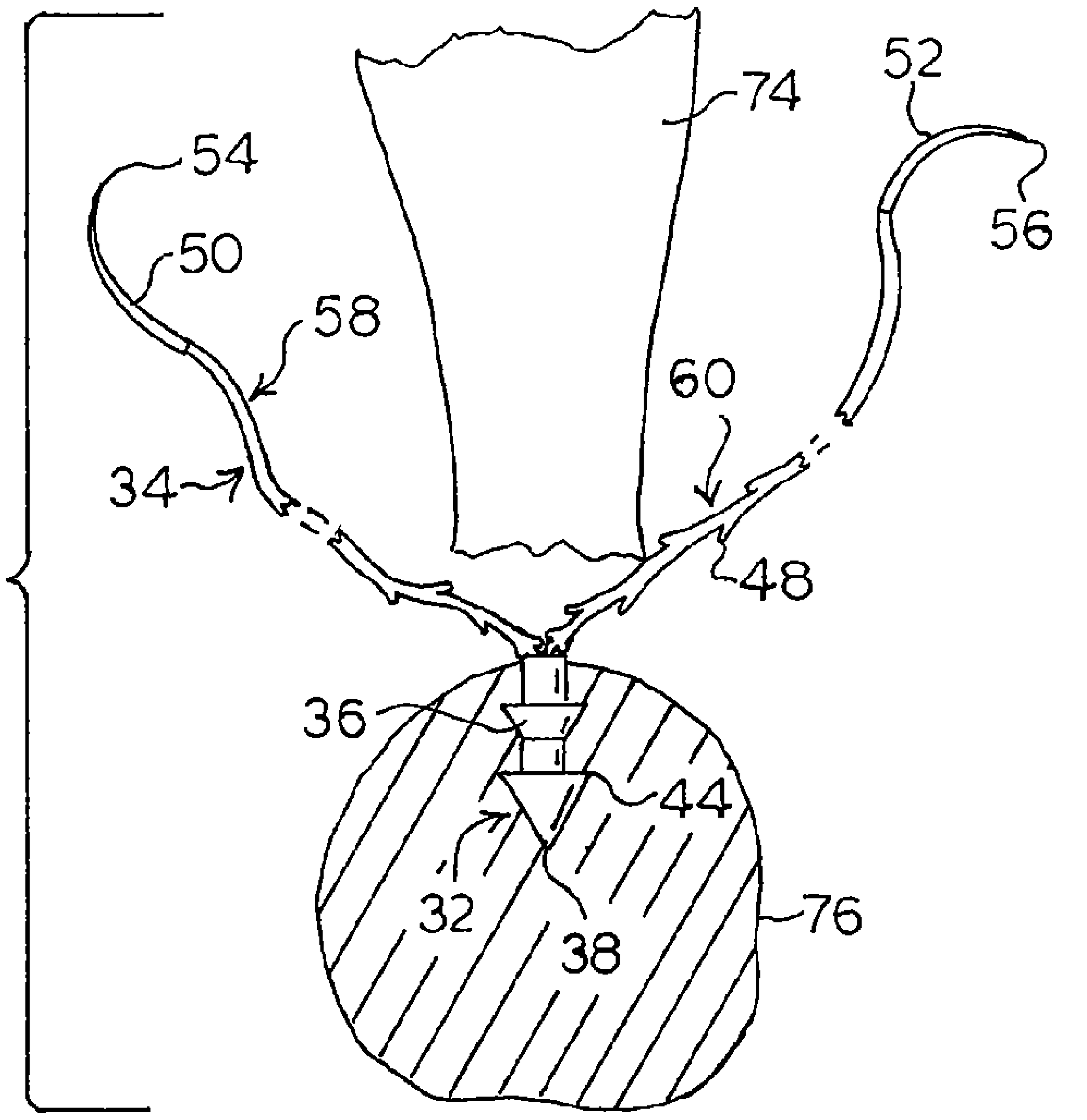
FIG. 2



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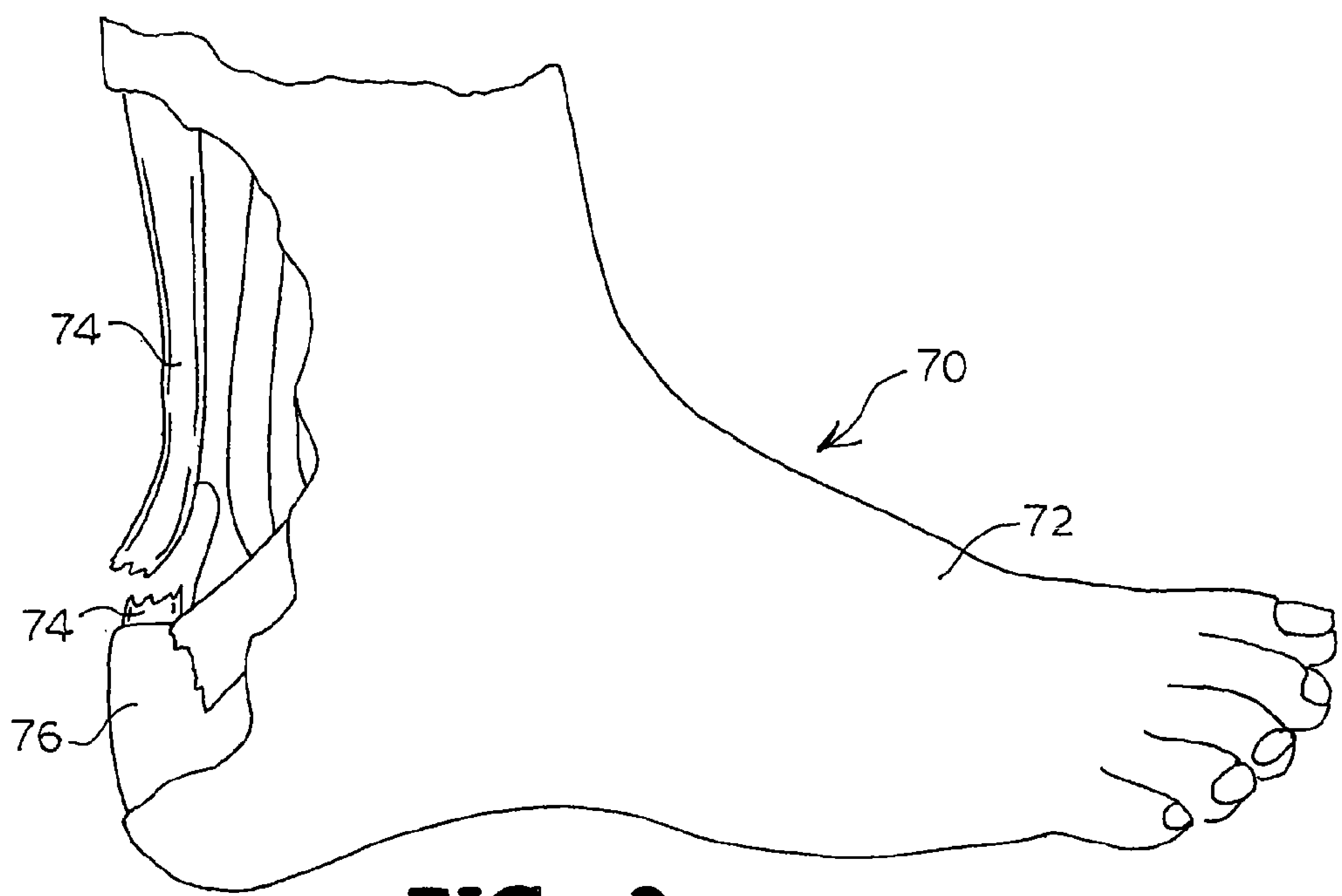

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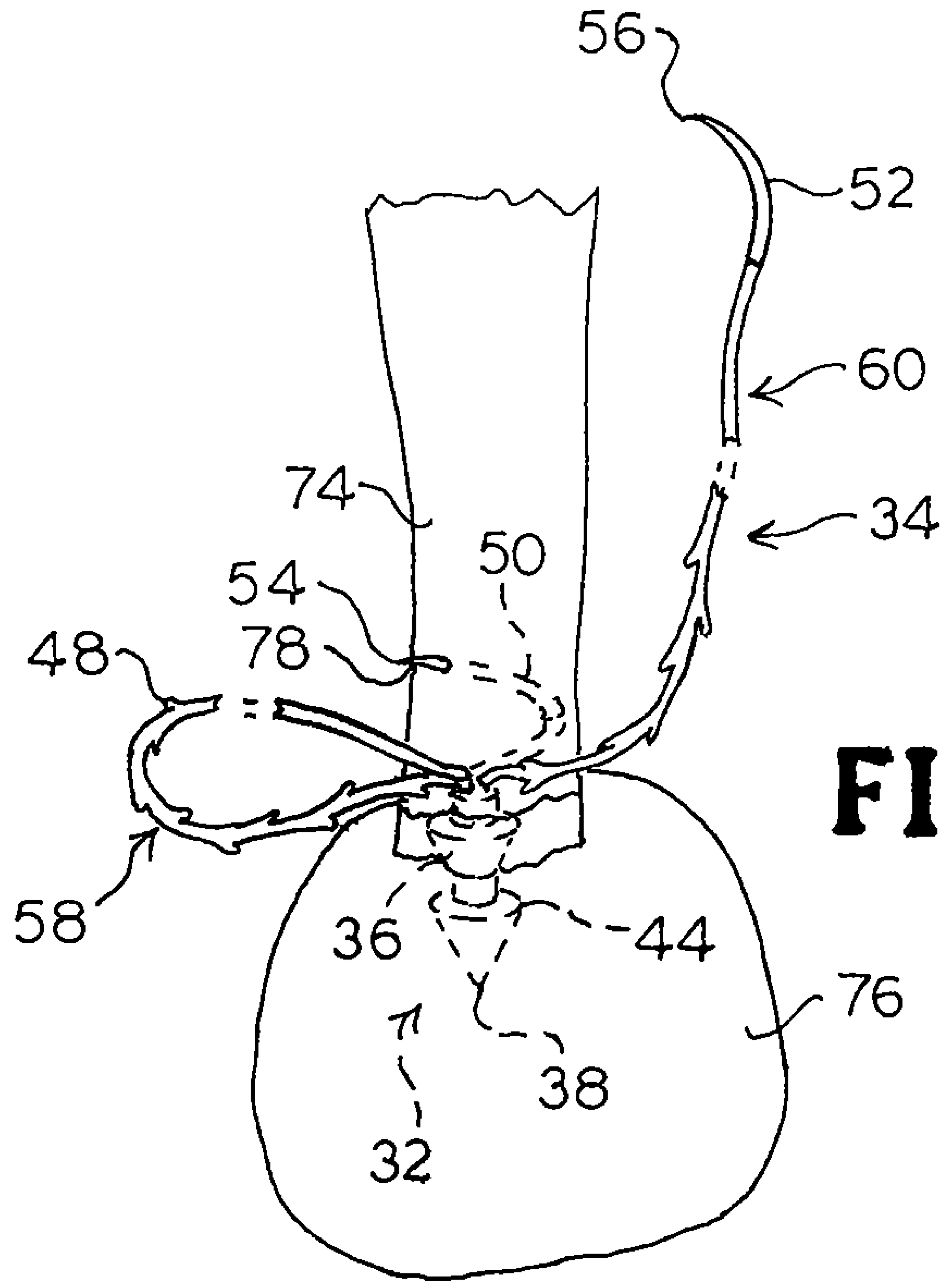
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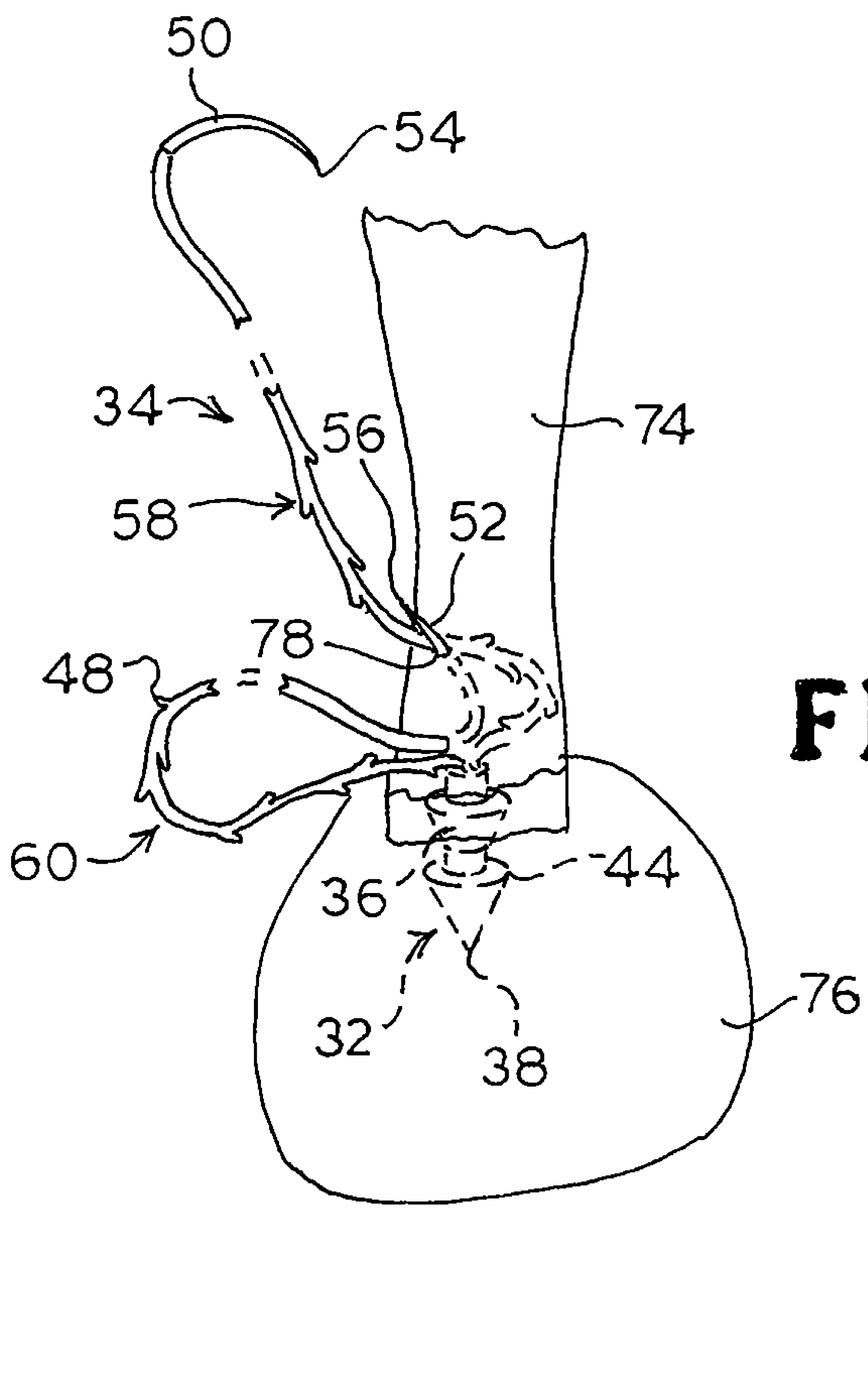
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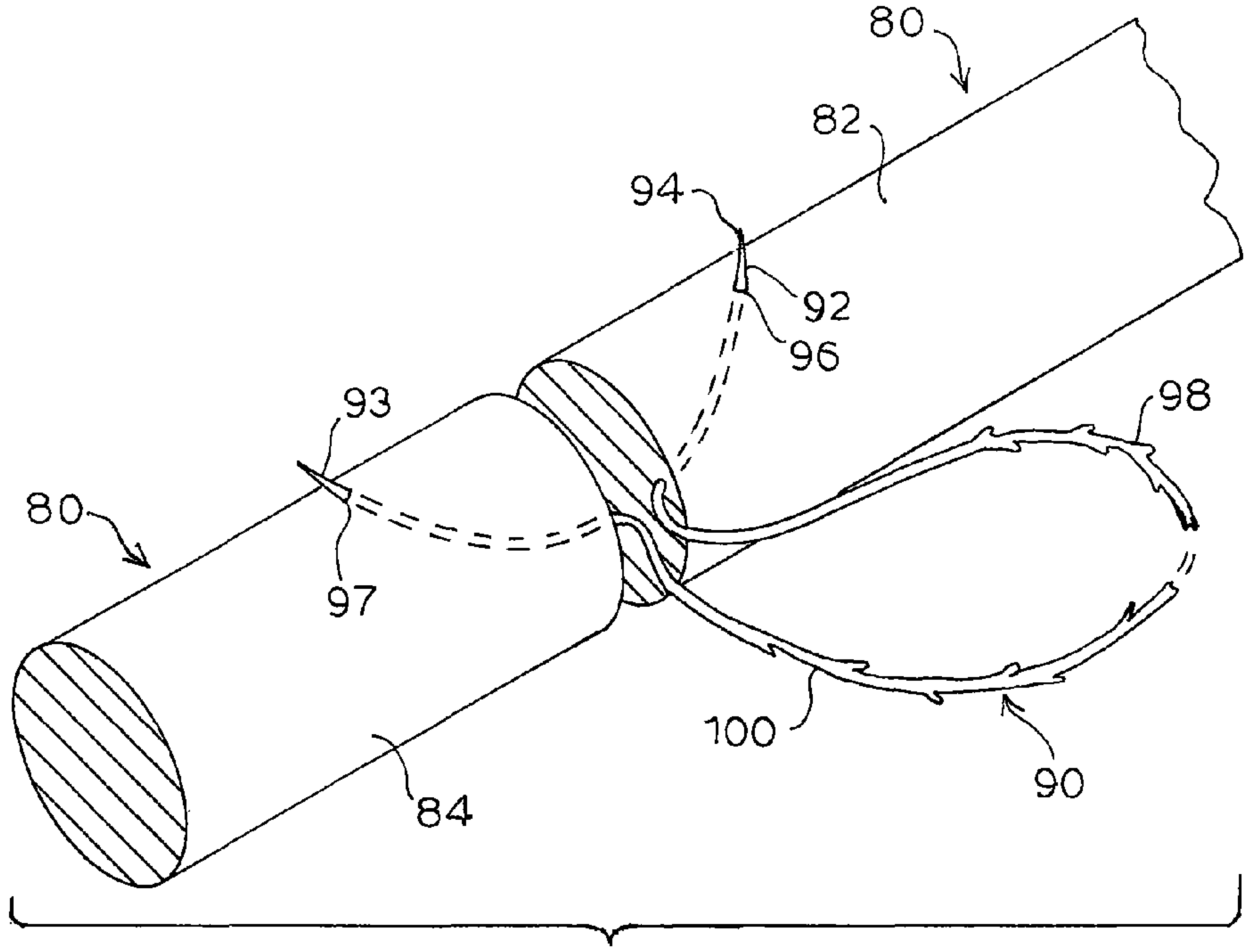
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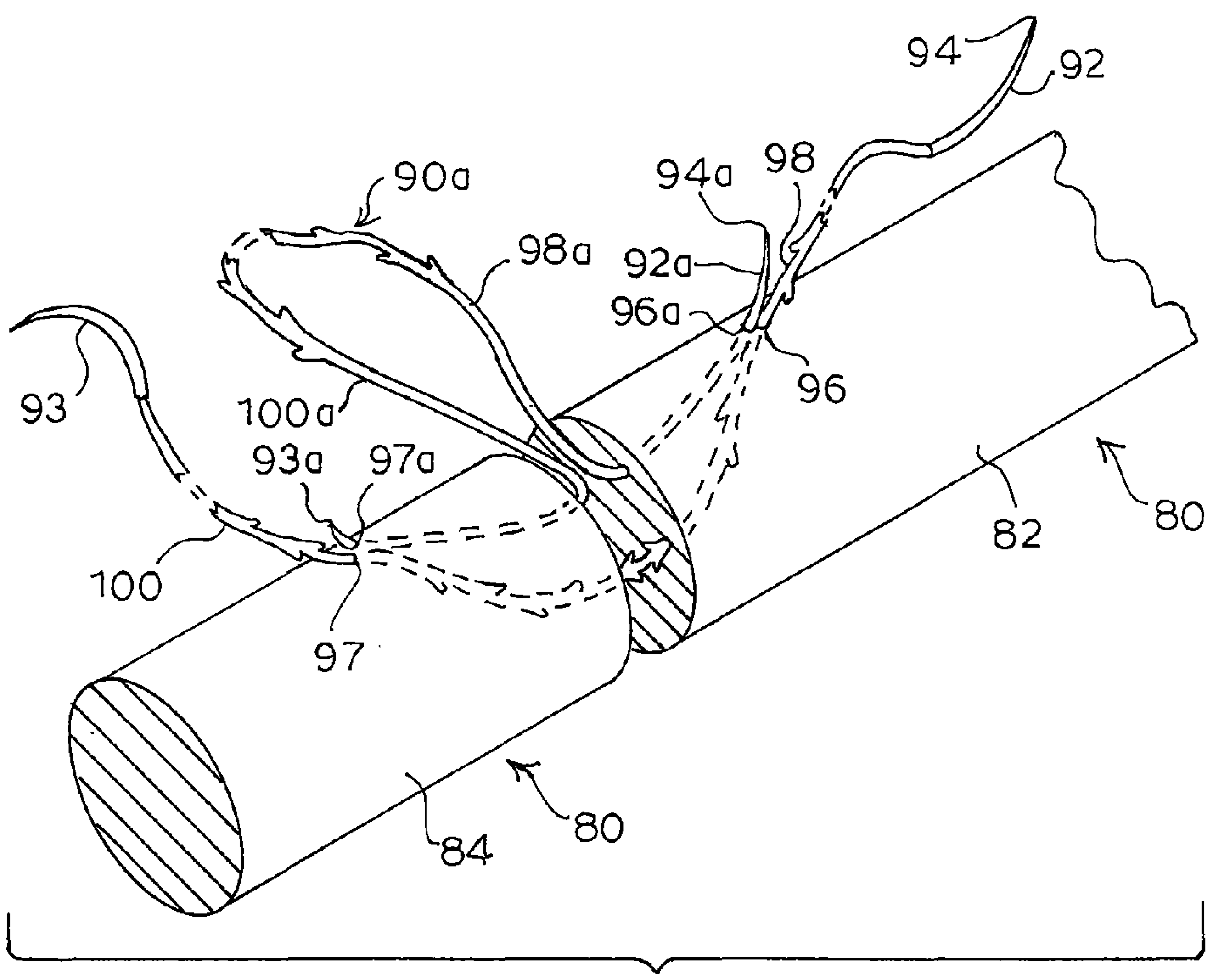
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FIG. 8

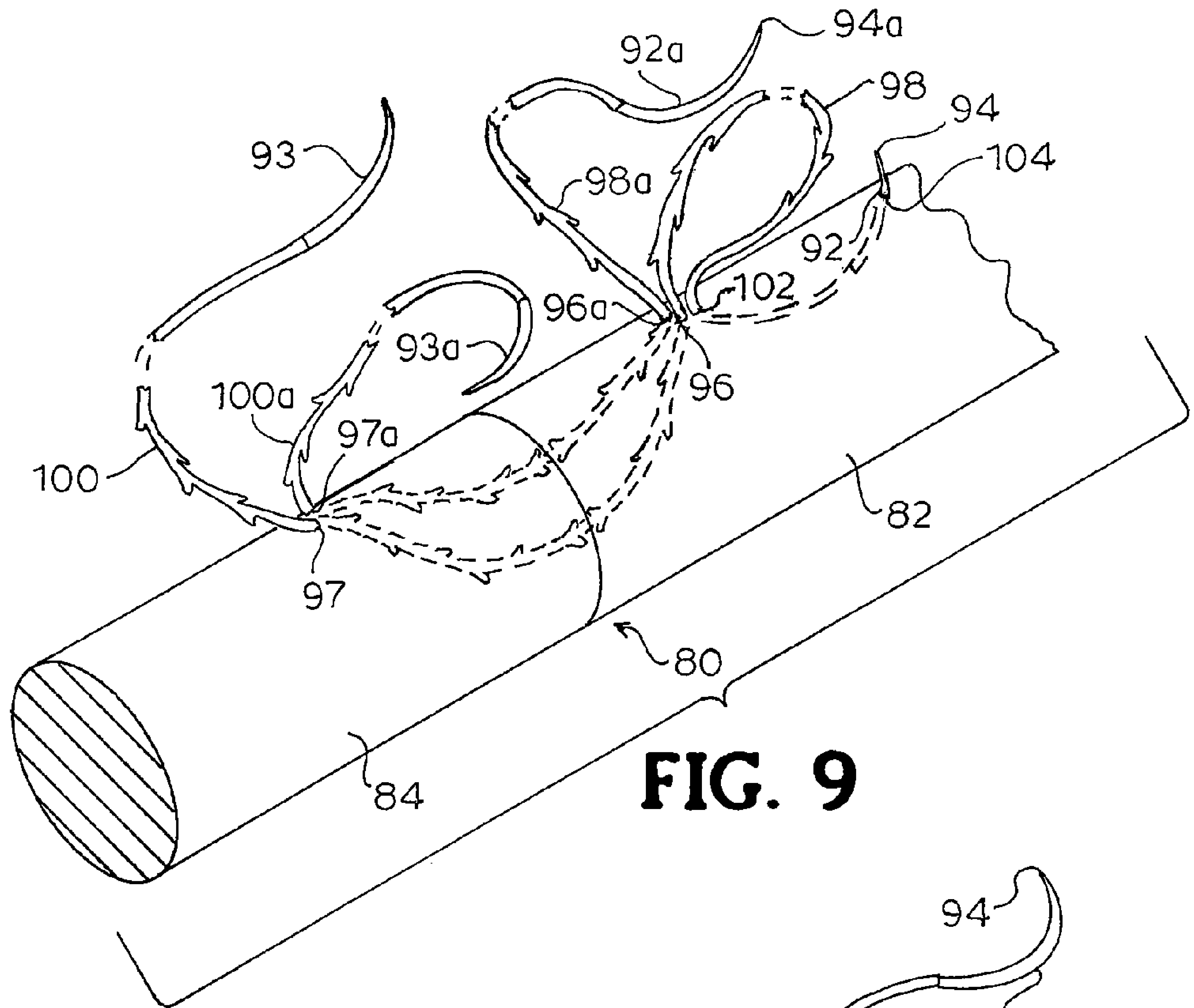
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FIG. 9

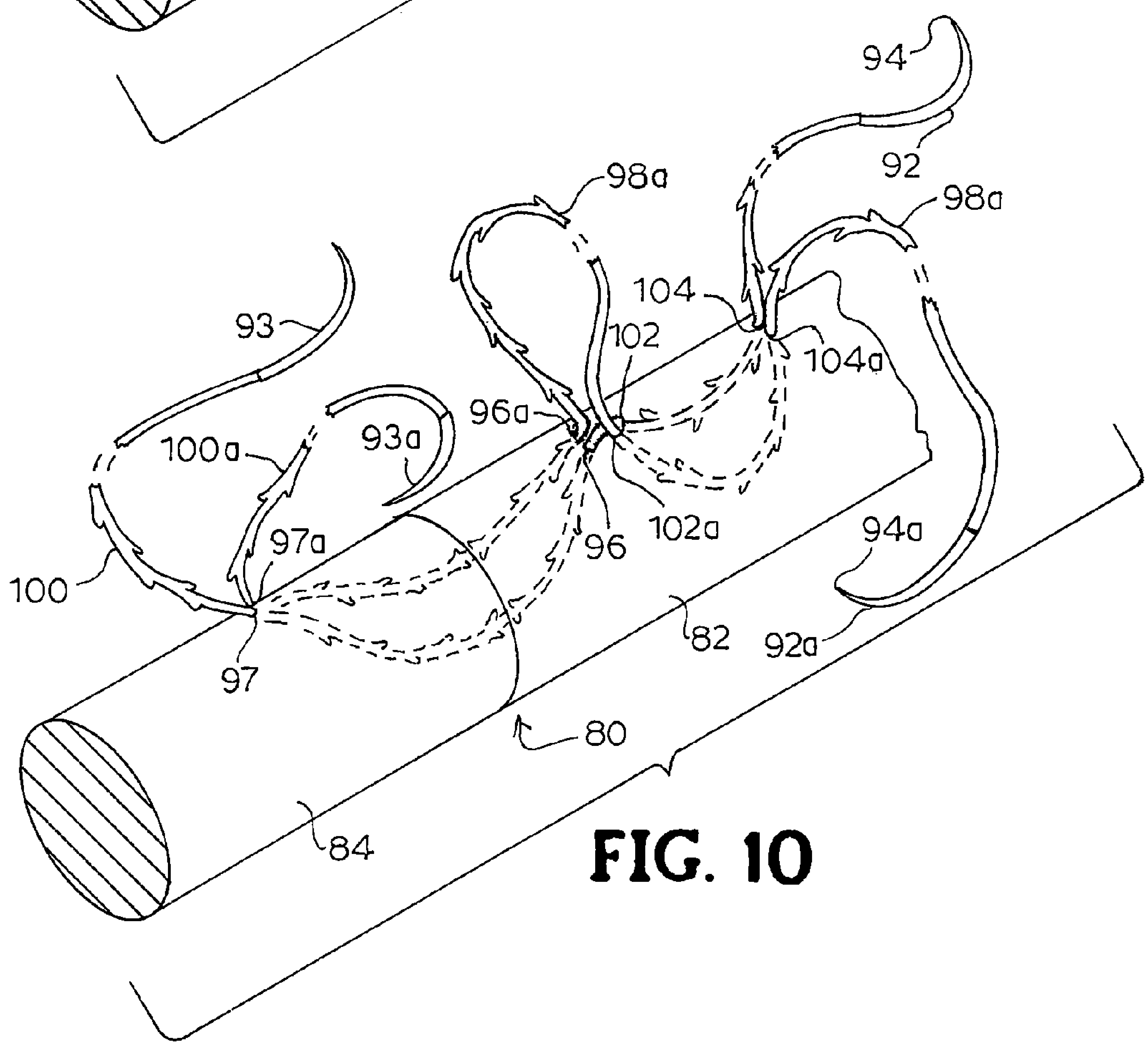
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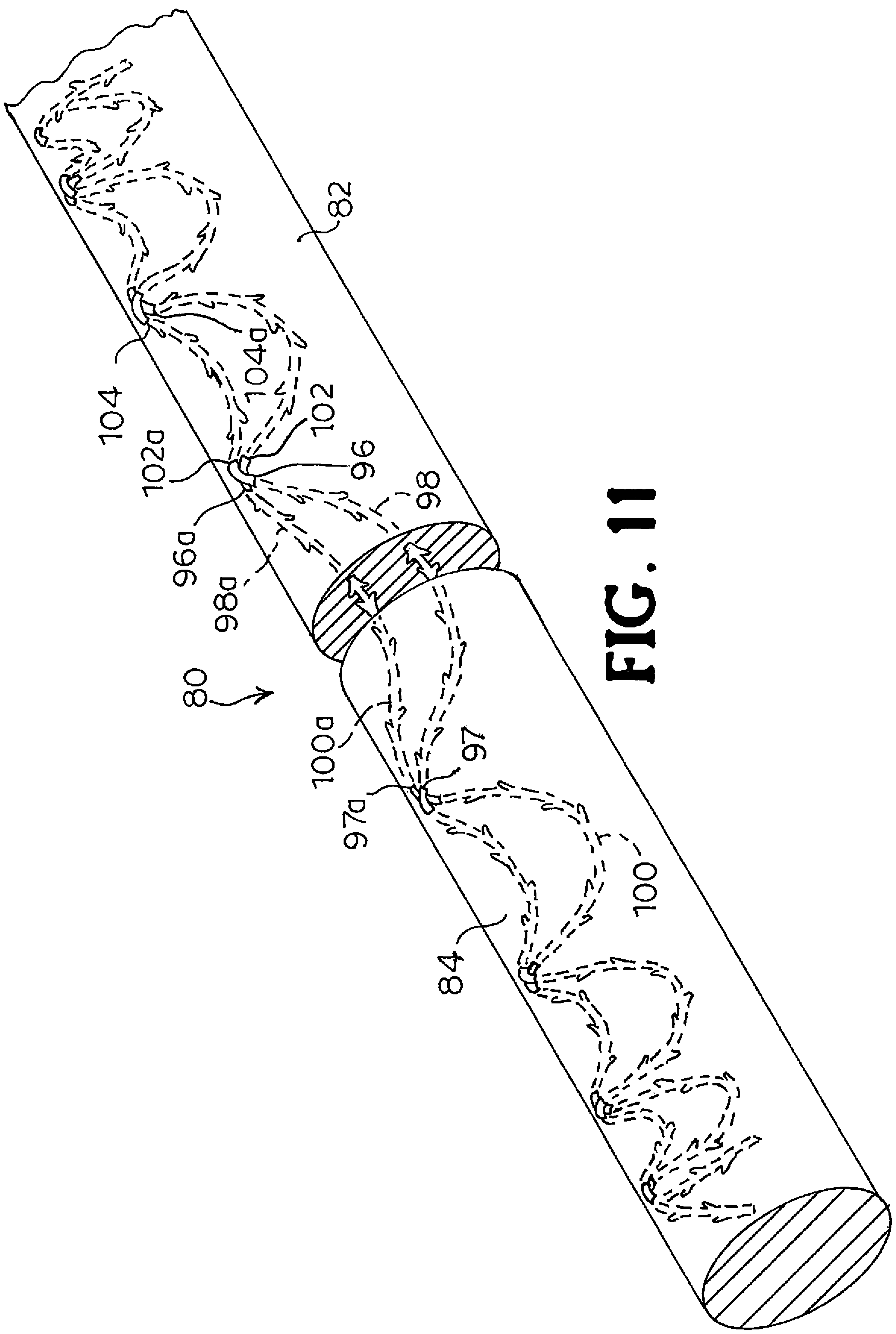
FIG. 10



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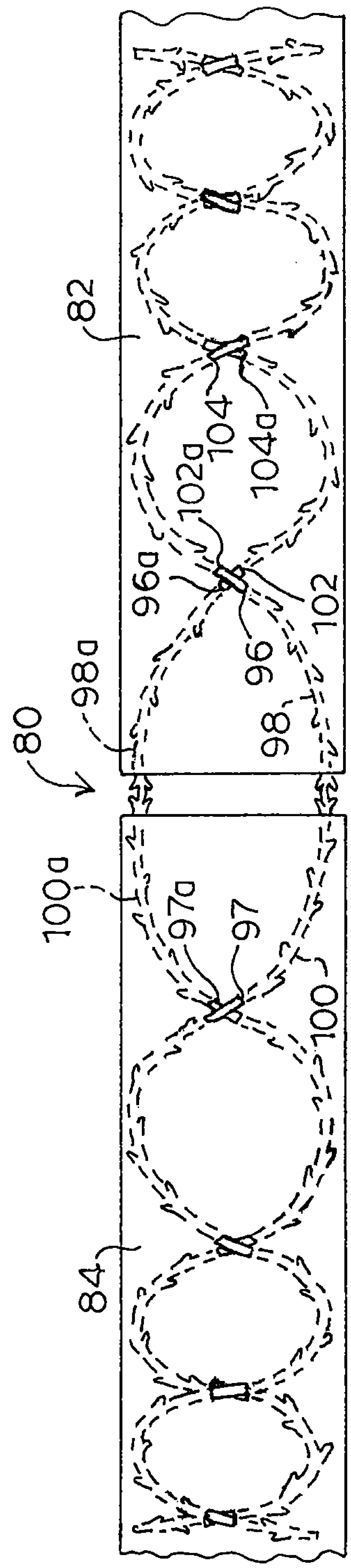
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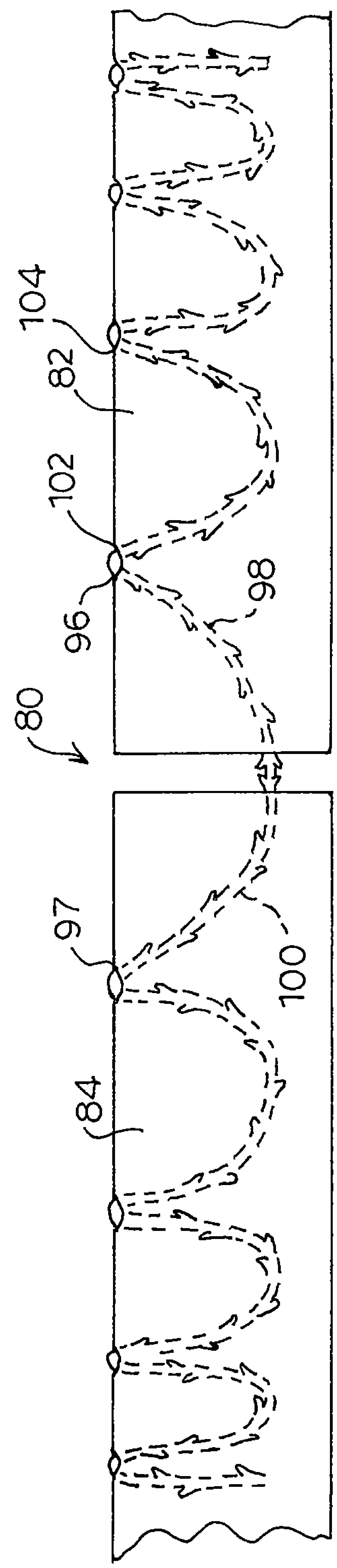
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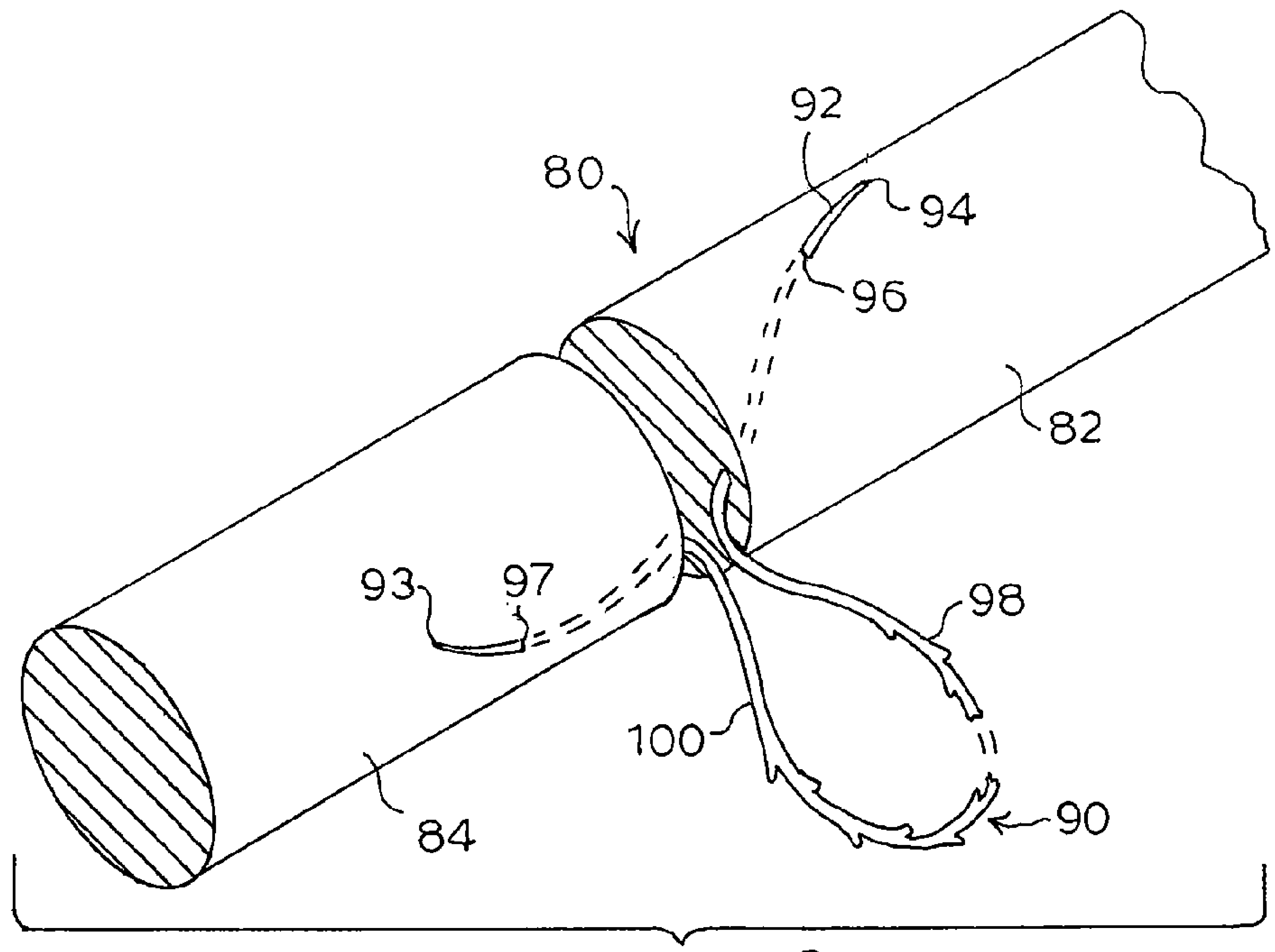
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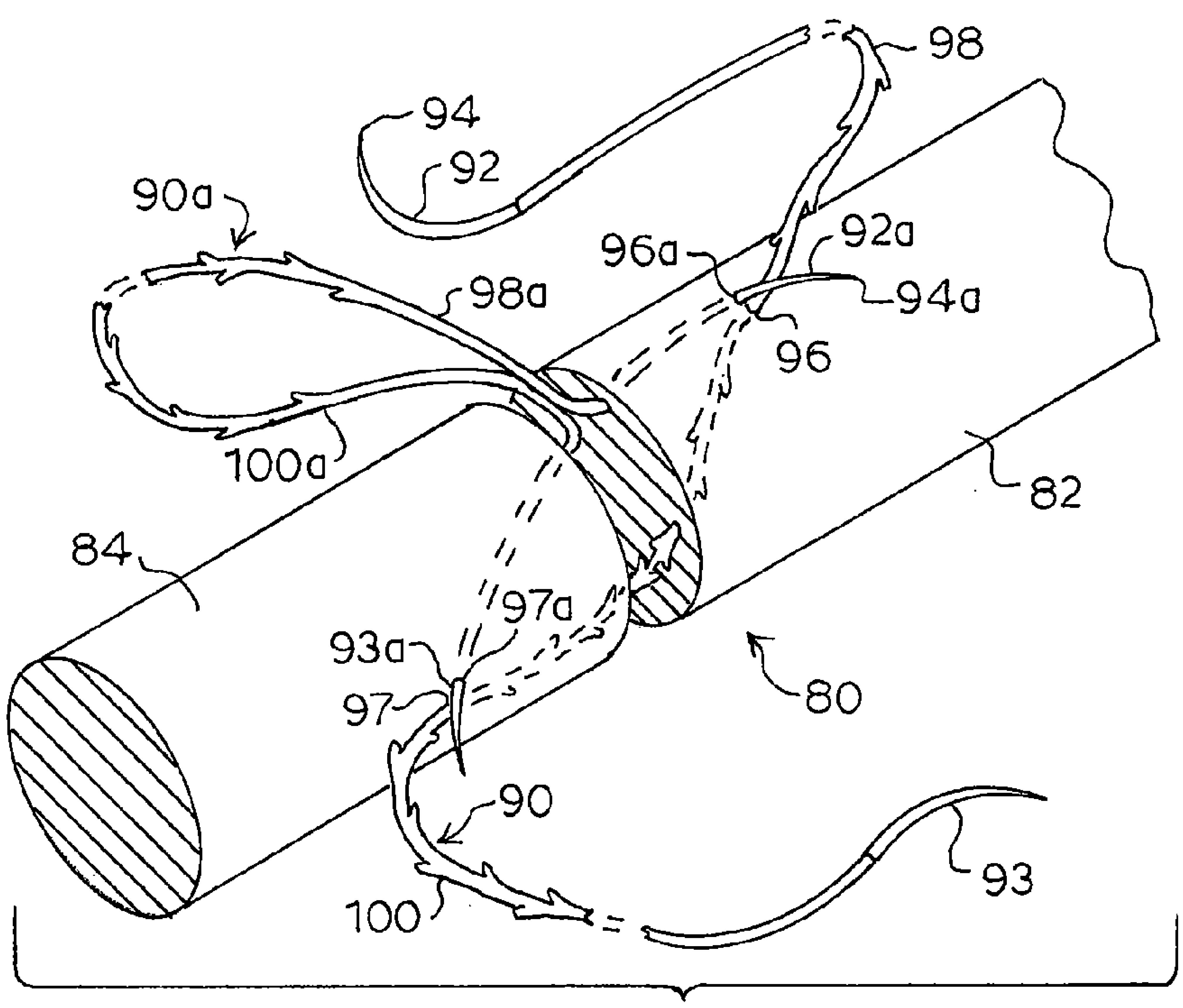
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FIG. 15

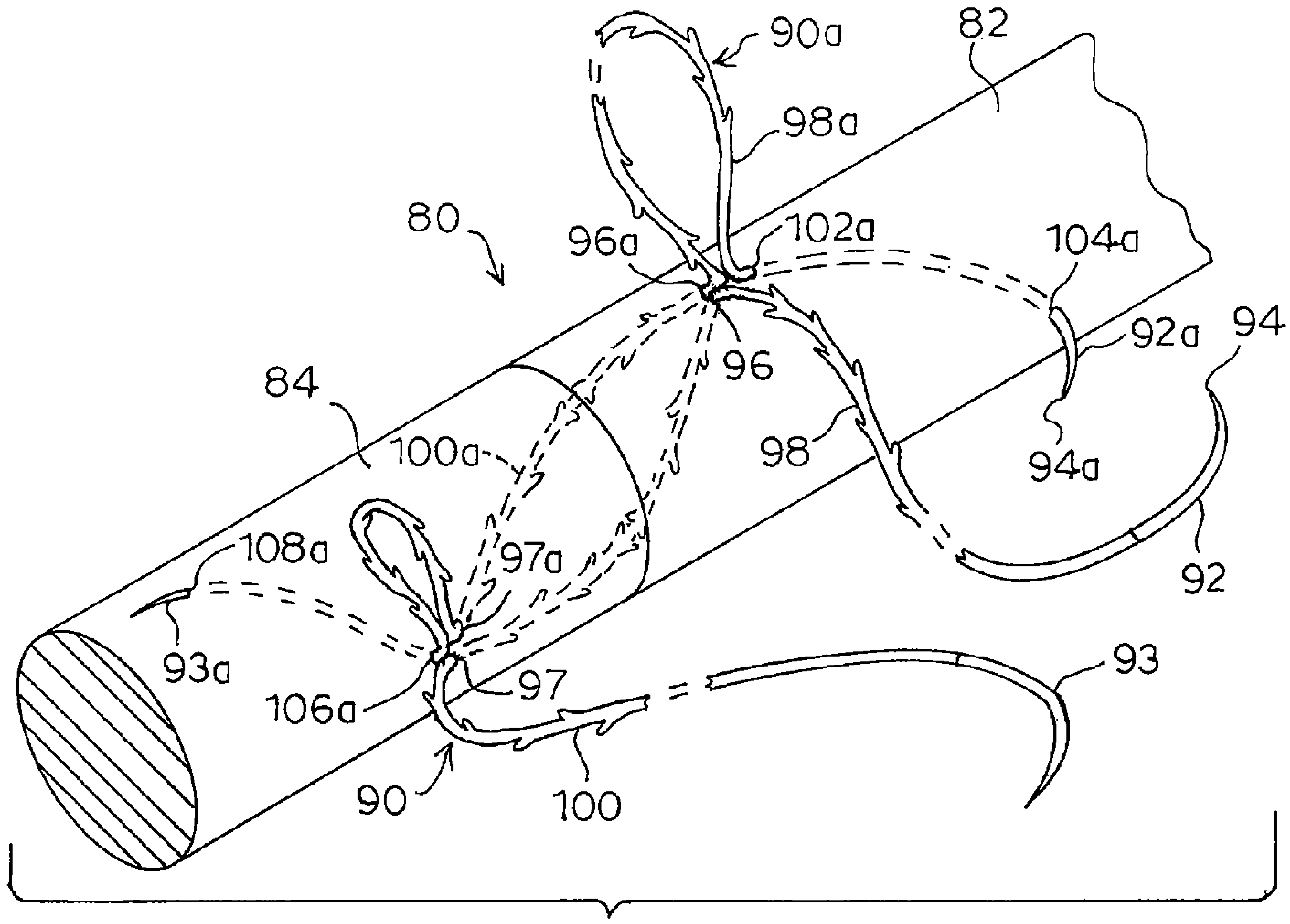
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FIG. 16

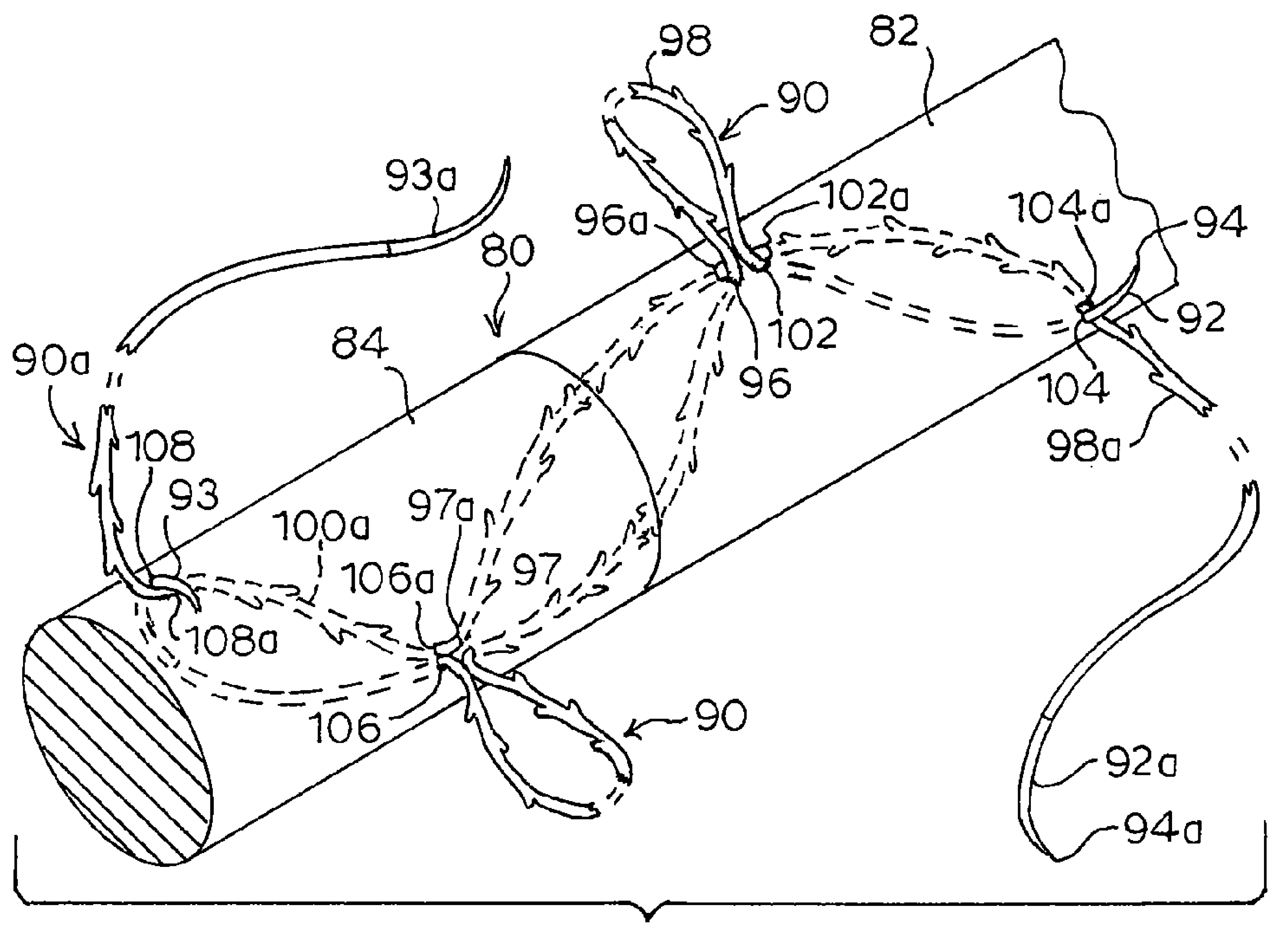
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FIG. 17

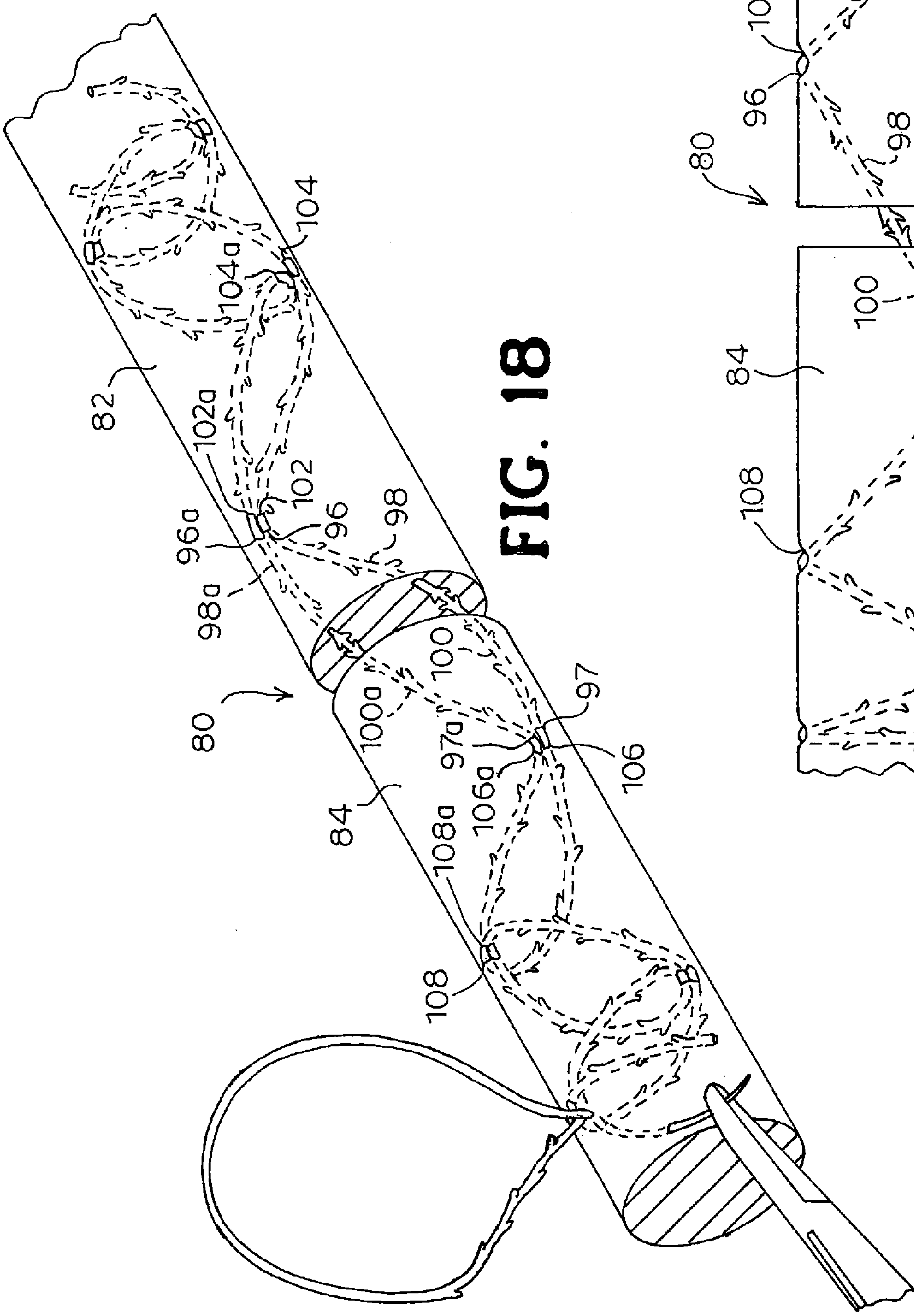
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FIG. 18

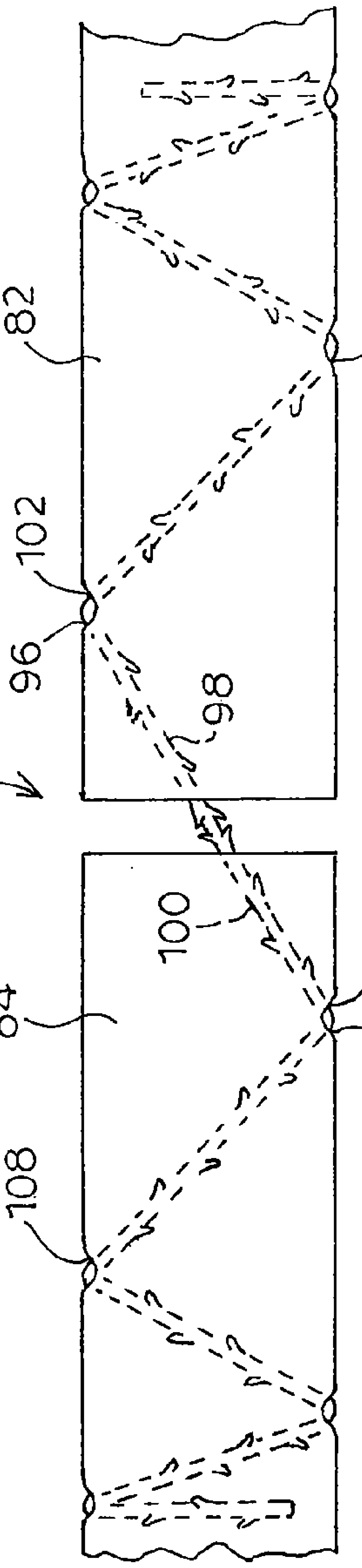
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FIG. 19

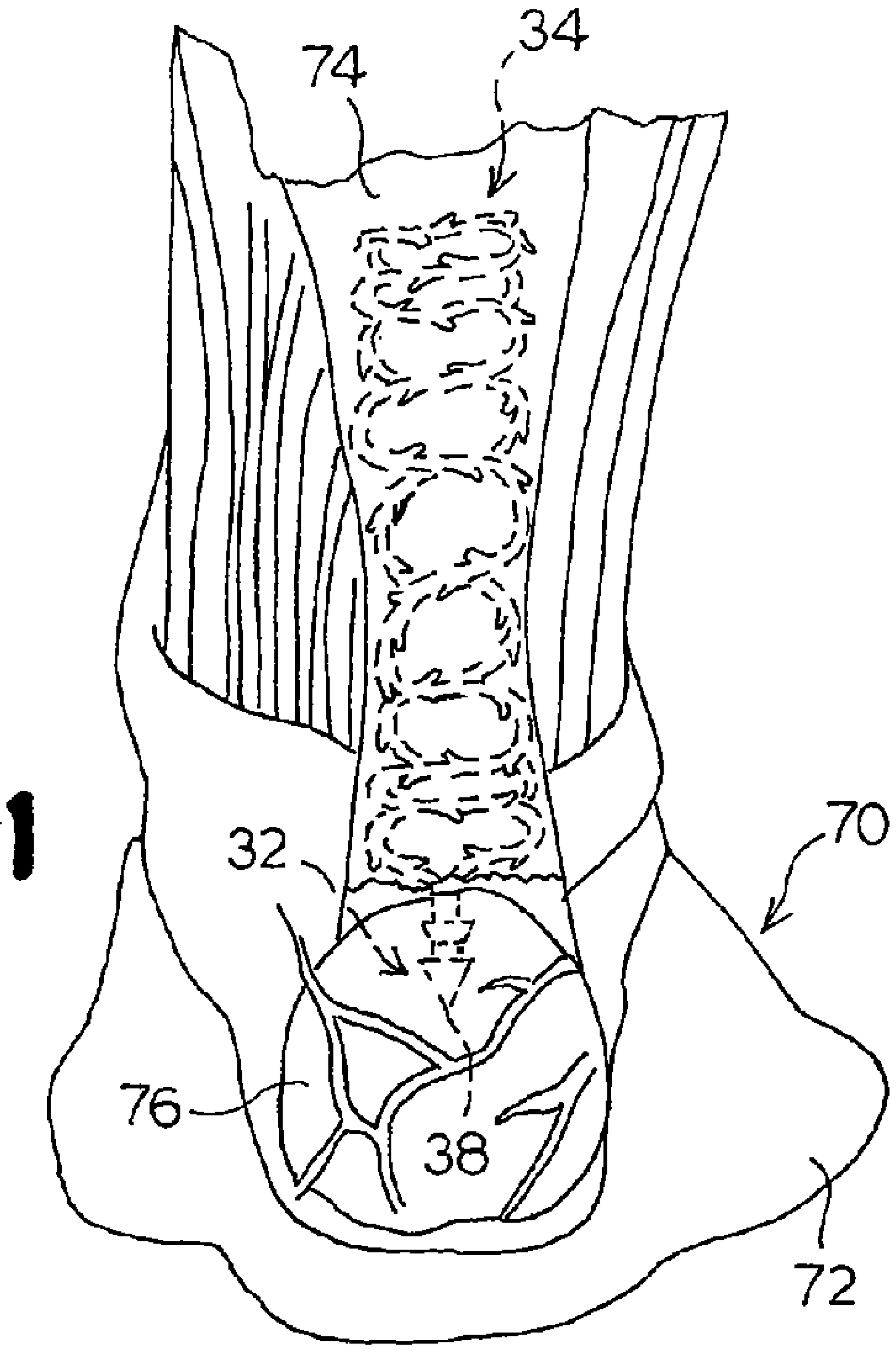

FIG. 21

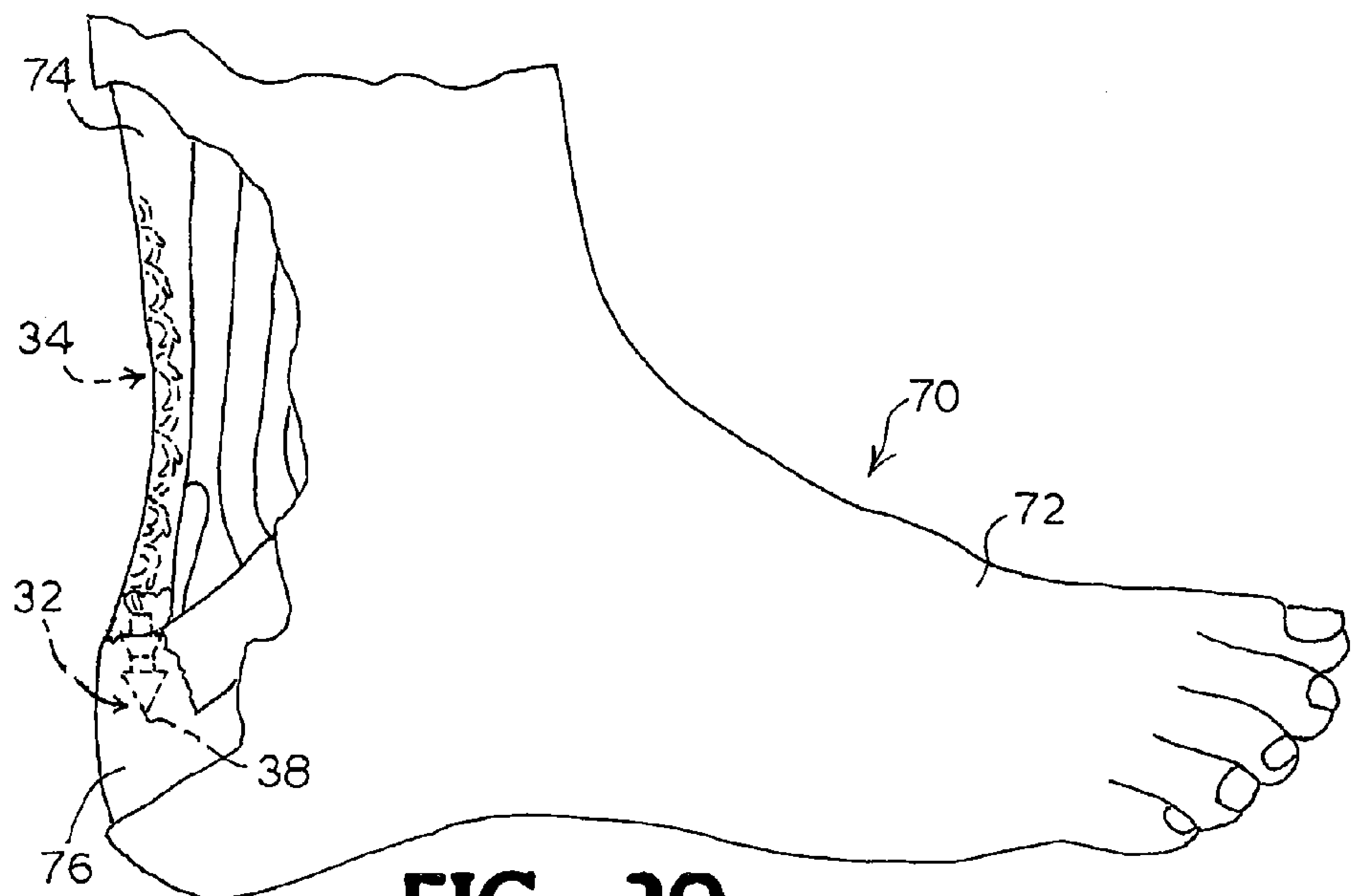

FIG. 20

MULTIPLE SUTURE THREAD CONFIGURATION WITH AN INTERMEDIATE CONNECTOR

CLAIM TO PRIORITY

This application is a continuation of U.S. application Ser. No. 12/119,749, filed May 13, 2008, now pending; which is a divisional of U.S. application Ser. No. 10/914,755, filed Aug. 9, 2004, now U.S. Pat. No. 7,371,253, issued May 13, 2008; which is a divisional of U.S. application Ser. No. 10/216,516, filed Aug. 9, 2002, now U.S. Pat. No. 6,773,450, issued Aug. 10, 2004. All of the above claimed priority applications are incorporated herein by reference in their entireties.

BACKGROUND OF THE INVENTION

This invention relates generally to a device and method for anchoring tissue within a body and, more particularly, to a suture anchor for use in surgical procedures requiring attachment of tissue, such as ligaments, tendons and the like, to other, preferably harder or more fibrous, tissue, such as a bone surface.

Suture anchors are used in surgical procedures wherein it is necessary for a surgeon to attach tissue to the surface of bone, for example, during joint reconstruction and ligament repair or replacement. Suture anchors generally comprise an anchor portion for fixed attachment to the bone, and a suture portion extending from the anchor portion used to connect the tissue to the bone. The anchor portion is often a generally cylindrical body having a sharp pointed end. An impact tool is typically used for driving the pointed end of the anchor into the bone. The outer surface of the anchor portion may be barbed or serrated to prevent the suture anchor from being withdrawn from the bone. The outer surface of the anchor portion could also be threaded and a driver, turned by a conventional drill, used to seat the threaded anchor portion into the bone. The anchor portion may also be fitted into a hole formed in the bone.

With the anchor portion securely in the bone, the suture portion is used for securing the tissue to the bone. The procedure typically involves passing a needle with the suture attached through the tissue. The tissue is advanced along the suture and tension is applied to the suture to draw the tissue tightly against the bone. The needle is removed and the tissue is secured against the bone by knotting the ends of the suture extending from the tissue. The knot is brought down to the surface of the tissue and tightened sufficiently to secure the tissue and bone in close approximation to promote reattachment and healing. A sliding retainer is sometimes used with the suture to pin the tissue against the bone.

There are other conventional suture anchors for attaching tissue to bone. For example, the anchor portion could take other forms including a staple which is driven into the bone surface with the suture positioned between the staple legs and the staple web fixing the suture to the bone surface. Also, a pair of closely-spaced holes can be drilled in the bone for passing the suture into one hole and out the other. However, these procedures are often difficult to perform, particularly in areas with limited access, such as deep wounds.

Further, conventional methods for approximating tissue to bone using a suture are difficult and inefficient because the procedure requires manipulation of the suture for securing the tissue in place. This is a time-consuming part of most surgical procedures, particularly in microsurgery and endoscopic surgery where there is insufficient space to properly manipulate the suture.

For the foregoing reasons, there is a need for an improved suture anchor for use in surgical procedures. The new suture anchor should eliminate the need for tying the suture to hold the tissue against the bone or other tissue surface. The method for using the suture anchor in surgical applications should allow a surgeon to approximate tissue to the bone or tissue surface in an efficient manner. A particularly useful new suture anchor would be used in surgical applications where space is limited such as microsurgery, endoscopic surgery or arthroscopic surgery.

SUMMARY OF THE INVENTION

According to the present invention, a suture anchor is provided for approximating tissue to bone or other tissue. The suture comprises an anchor member adapted to fixedly engage the bone for securing the anchor member relative to the bone. A plurality of sutures are mounted to the proximal end of the anchor member so that the sutures extend outwardly from the anchor member. Each suture has a sharp pointed distal end for penetrating the tissue and a plurality of barbs extending from the periphery of the body. The barbs permit movement of the sutures through the tissue in a direction of movement of the pointed end and prevent movement of the sutures relative to the tissue in a direction opposite the direction of movement of the pointed end.

Also according to the present invention, a method is provided for approximating tissue to a bone or other tissue to allow reapproximation and healing of the tissue and bone in vivo. The method uses a suture anchor including an anchor member adapted to be fixedly mounted to the bone and a plurality of sutures extending from the anchor member. The method comprises the steps of providing on each suture a sharp pointed distal end for penetrating the tissue and a plurality of barbs extending from the periphery of the body. The barbs permit movement of the sutures through the tissue in a direction of movement of the pointed end and prevent movement of the sutures relative to the tissue in a direction opposite the direction of movement of the pointed end. The anchor member is secured in the bone such that the sutures extend from the bone surface and a pointed end of a first suture is inserted into the tissue. The end of the first suture is pushed through the tissue along a curvilinear path in a direction away from the bone until the point at the end of the first suture extends out of the tissue at an exit point in the periphery of the tissue longitudinally spaced from the point of insertion. The pointed end of the first suture is gripped and pulled out of the tissue for drawing the first suture through the tissue while approximating the tissue adjacent the bone along the suture and leaving a length of the first suture in the tissue. The pointed end of the first suture is then inserted into the periphery of the tissue adjacent the exit point and pushed through the tissue along a curvilinear path in the direction away from the bone until the pointed end of the first suture extends out of the tissue at an exit point in the periphery of the tissue longitudinally spaced from the previous insertion point. The pointed end of the first suture is gripped and pulled out of the tissue for drawing the first suture through the tissue leaving a length of the first portion of the suture in the tissue. These steps are repeated with the first suture for advancing longitudinally along the tissue in the direction away from the bone. A second suture is then introduced into the tissue and the previous steps repeated so that the exit and entry points of the second suture are adjacent the corresponding exit and entry points of the first suture and the path of the second suture substantially mirrors the path of the first suture.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, reference should now be had to the embodiments shown in the accompanying drawings and described below. In the drawings:

FIG. **1** is a perspective view of an embodiment of a suture anchor according to the present invention;

FIG. **2** is a perspective view of another embodiment of a suture anchor including a plurality of barbed sutures according to the present invention;

FIG. **3** is a side elevation view of an ankle with a portion of the outer layer of tissue cut-away to schematically show a torn Achilles tendon;

FIGS. **4-6** are schematic views of an embodiment of a method according to the present invention for reattaching the Achilles tendon to bone;

FIGS. **7-10** are perspective views of a method for joining two ends of a severed tendon according to the present invention;

FIGS. **11-13** are perspective, side and top plan views, respectively, of the suture pattern generated by the method shown in FIGS. **7-10**;

FIGS. **14-17** are perspective views of another method for joining two ends of a severed tendon according to the present invention;

FIGS. **18** and **19** are perspective and side elevation views, respectively, of the suture pattern generated by the method shown in FIGS. **14-17**; and

FIGS. **20** and **21** are side and rear elevation views, respectively, of the ankle shown in FIG. **3** with the torn Achilles tendon reattached to the bone using the suture anchor and method shown in FIGS. **7-13** according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As used herein, the term "tissue" includes tendons, ligaments, cartilage, muscle, skin, organs, and other soft tissue. The term "bone" includes bone, cartilage, tendon, ligament, fascia, and other connective or fibrous tissue suitable for anchor for a suture.

Certain other terminology is used herein for convenience only and is not to be taken as a limitation on the invention. For example, words such as "upper," "lower," "left," "right," "horizontal," "vertical," "upward," and "downward" merely describe the configuration shown in the FIGs. It is understood that the components may be oriented in any direction and the terminology, therefore, should be understood as encompassing such variations unless specified otherwise.

Referring now to the drawings, wherein like reference numerals designate corresponding or similar elements throughout the several views, there is shown in FIG. **1** a suture anchor for use according to the present invention and generally designated at **30**. The suture anchor **30** includes an anchor portion **32** and a suture portion **34**. The anchor portion **32** comprises an elongated body **36** having a distal pointed tip **38** which serves as a leading end of the suture anchor **30** when the suture anchor is inserted into bone. A blind bore **40**, or opening, is formed at the proximal end **41** of the anchor portion **32**. A crossbar **42** integral with the anchor body **36** spans the opening **40** for threadably receiving the suture portion **34** at the proximal end of the anchor portion **32**.

The anchor portion **32** is shown as having a circular cross-section, although other cross-sectional shapes could be utilized without departing from the present invention. As shown in FIG. **1**, ridges **44**, or barbs, may be formed on the outer surface of the anchor portion **32** which allow movement of the anchor portion **32** through bone in one direction but which resist the withdrawal of the anchor portion **32** after the anchor portion has been implanted in the bone.

As described above, the anchor portion **32** is driven into the bone surface, pointed tip **38** first, by impact against the proximal end **41**, or by turning as when the anchor portion **32** is threaded (not shown). The anchor portion **32** can also be disposed into a hole bored in the bone, in which case insertion can be accomplished with direct pressure or gentle tapping on the proximal end **41** of the anchor portion **32**. The ridges **44** on the surface of the anchor body **36** grasp the bone rendering the anchor portion **32** substantially irremovable from the bone. Tension on the suture portion **34** enhances this effect.

The suture portion **34** of the suture anchor **30** has an elongated body **46** and a plurality of barbs **48** disposed along the length of the body **46**. First and second ends **50**, **52** of the suture body **46** terminate in points **54**, **56** for penetrating tissue. The body **46** of the suture portion **34** is, in one embodiment, circular in cross section. Suitable diameters for the body **46** range from about 0.001 mm to about 5.0 mm. The body **46** of the suture portion **34** could also have a non-circular cross-sectional shape which would increase the surface area of the body **46** and facilitate the formation of multiple barbs **48**. The length of the suture portion **34** can vary depending on several factors, including the desired surgical application, the type of tissue to be approximated to the bone, the location of the bone, and the like. A suture portion **34** of proper length is selected for achieving suitable results in a particular application.

The plurality of barbs **48** is axially-spaced along the body **46** of the suture portion **34**. The barbs **48** are oriented in one direction facing toward the first end **50** of the suture body **46** for a first portion **58** of the length of the suture portion **34** and in an opposite direction facing the second end **52** of the suture body **46** for a second portion **60** of the suture portion **34**. The point on the suture body **46** where the barbs **48** change direction is preferably positioned adjacent the crossbar **42** at the proximal end of the anchor body **36**. The barbs **48** are yieldable toward the body **46**. The barbs **48** on each portion **58**, **60** of the suture body **46** are oriented so as to allow movement of the suture portion **34** through the tissue in one direction along with the corresponding end **50**, **52** of the suture portion **34**. The barbs **48** are generally rigid in an opposite direction to prevent the suture body **46** from moving in the tissue in the opposite direction.

The barbs **48** can be arranged in any suitable pattern, for example, in a helical pattern as shown in FIG. **1**. The number, configuration, spacing and surface area of the barbs **48** can vary depending upon the tissue in which the suture portion **34** is used, and depending on the composition and geometry of the suture body **46**. The proportions of the barbs **48** may remain relatively constant while the overall length and spacing of the barbs **48** are determined by the tissue being approximated to the bone. For example, if the suture portion **34** is intended to be used in tendon, the barbs **48** can be made relatively short and more rigid to facilitate entry into this rather firm, fibrous tissue. If the suture portion **34** is intended for use in soft tissue, such as fat, the barbs **48** can be made longer and spaced farther apart to increase the holding ability in the soft tissue. Moreover, the ratio of the number of barbs **48** on the first portion **58** of the suture body **46** to the number of barbs **48** on the second portion **60**, and the lengths of each portion **58**, **60**, can vary depending on the surgical application and needs.

The surface area of the barbs **48** can also vary. For example, fuller-tipped barbs **48** can be made of varying sizes designed for specific surgical applications. For joining fat and relatively soft tissues, larger barbs **48** are desired, whereas smaller barbs **48** are more suited for collagen-dense tissues. There are also situations where a combination of large and small barbs **48** within the same structure will be beneficial such as when the suture portion **34** is used in the repair of tissue with differing layered structures. Use of the combination of large and small barbs **48** with the same suture portion **34** wherein barb **48** sizes are customized for each tissue layer will ensure maximum anchoring properties.

The barbs **48** may be formed on the surface of the suture body **46** according to any suitable method, including cutting, molding, and the like. The preferred method is cutting with acute angular cuts directly into the suture body **46** with the cut portions pushed outwardly and separated from the body **46**. The depth of the barbs **48** formed in the suture body **46** depends on the diameter of the suture material and the depth of cut. Embodiments of a suitable cutting device for cutting a plurality of axially spaced barbs **48** on the exterior of suture filaments are shown and described in U.S. patent application Ser. No. 09/943,733, entitled "Method Of Forming Barbs On A Suture And Apparatus For Performing Same", which was filed on Aug. 31, 2001, the contents of which are hereby incorporated by reference. This cutting device utilizes a cutting bed, a cutting bed vise, a cutting template, and a blade assembly to perform the cutting. When operated, the cutting device has the ability to produce a plurality of axially spaced barbs **48** in the same or random configuration and at different angles in relation to each other. Various other suitable methods of cutting the barbs **48** have been proposed including the use of a laser. The barbs **48** could also be cut manually. However, manually cutting the barbs **48** is labor intensive, decreases consistency, and is not cost effective. The suture portion **34** could also be formed by injection molding, extrusion, stamping and the like.

Barbed sutures suitable for use according to the methods of the present invention are described in U.S. Pat. No. 5,342,376, entitled "Inserting Device for a Barbed Tissue Connector", U.S. Pat. No. 6,241,747, entitled "Barbed Bodily Tissue Connector", and U.S. Pat. No. 5,931,855. The contents of U.S. Pat. No. 5,342,376, U.S. Pat. No. 5,931,855 and U.S. Pat. No. 6,241,747 are hereby incorporated by reference.

The suture portion **34** is attached to the proximal end of the anchor portion **32**. As seen in FIG. **1**, the suture portion **34** is threaded around the crossbar **42** on the anchor body **36**. It is understood that the suture portion **34** may be attached to the anchor portion **32** in a number of ways, including inserting the end of the suture body **46** into the bore **40** formed in the proximal end of the anchor body **36** and securing the suture body **46** in place with a set screw, rivet, or the like, or, wherein the material of the anchor portion **32** is metal, by swaging or crimping. The anchor portion **32** and suture portion **34** could also be formed in one piece in the manufacturing process. However, the preferred attachment of the suture portion **34** is as shown in FIG. **1** since this arrangement allows a simple, secure threading of a double-ended suture portion **34** during manufacture or prior to use. Moreover, as seen in FIG. **2**, the user may selectively attach several suture portions **34** to the anchor portion **32** depending upon the surgical application.

Suitable material for the body **46** of the suture portion **34** is available in a wide variety of monofilament suture material. The particular suture material chosen depends on strength and flexibility requirements. In one embodiment, the material for the suture body **46** is flexible and substantially nonresilient so that the shape of an inserted suture portion **34** will be determined by the path of insertion and the surrounding tissue. In some applications, however, it may be desirable for at least a portion of the suture body **46** to have sufficient dimensional stability to assume a substantially rigid configuration during use and sufficient resiliency to return to a predetermined position after deflection therefrom. The portions of the ends **50**, **52** of the suture body **46** adjacent the points **54**, **56** may be formed of a material sufficiently stiff to enable the points **54**, **56** to penetrate tissue in which the suture portion **34** is used when a substantially axial force is applied to the body **46**. Variations in surface texture of the suture body **46** can impart different interaction characteristics with the tissue.

The ends **50**, **52** of the suture portion **34** may be straight (FIG. **1**) or curved (FIG. **2**). In one embodiment, the ends **50**, **52** of the suture portion **34** may be surgical needles secured at each end of the suture portion **34** so that the body **46** extends between the shank ends of the two needles. The needles are preferably constructed of stainless steel or other surgical-grade metal alloy. The needles may be secured to the suture body **46** by means of adhesives, crimping, swaging, or the like, or the joint may be formed by heat shrinkable tubing. A detachable connection may also be employed such that the needles may be removed from the suture body **46** by a sharp tug or pull or by cutting. The length of the needles is selected to serve the type of tissue being repaired so that the needles can be completely removed leaving the suture body **46** in the desired position within the tissue.

The suture anchor **30** of the present invention can be formed of a bioabsorbable material which allows the suture anchor **30** to be absorbed by the body over time. Bioabsorbable material is particularly useful in arthroscopic surgery and procedures. Many compositions useful as bioabsorbable materials can be used to make the suture anchor **30**. Generally, bioabsorbable materials are thermoplastic polymers. Selection of the particular material is determined by the desired absorption or degradation time period which depends upon the anticipated healing time for the subject of the procedure. Biodegradable polymers and co-polymers range in degradation time from about one month to over twenty-four months. They include, but are not limited to, polydioxanone, polylactide, polyglycolide, polycaprolactone, and copolymers thereof. Other copolymers with trimethylene carbonate can also be used. Examples are PDS II (polydioxanone), Maxon (copolymer of 67% glycolide and 33% trimethylene carbonate), and Monocryl (copolymer of 75% glycolide and 25% caprolactone). Germicides can also be incorporated into the suture anchor **30** to provide long lasting germicidal properties.

Alternatively, either the anchor portion **32** or the suture portion **34** of the suture anchor **30** can be formed from non-absorbable material such as, for example, nylon, polyethylene terephthalate (polyester), polypropylene, and expanded polytetrafluoroethylene (ePTFE). The suture body **46** can also be formed of metal (e.g. steel), metal alloys, or the like. Titanium is a preferred material when the anchor portion **32** is to remain permanently in the bone. A suitable anchor portion **32** for use according to the present invention is available from Mitek Products of Norwood, Mass. Alternatively, the anchor portion **32** can also be a rigid barbed structure made from thick monofilament suture material with barbs suitable for anchoring in bone.

In use in an orthopedic surgical procedure, the anchor portion **32** of the suture anchor **30** of the present invention is inserted into bone. Once the anchor portion **32** is fixed in place, the suture portion **34** extends outwardly from the anchor portion **32** and the bone for surgical suturing to tissue to be approximated to the bone. The tissue is brought into position over the suture anchor **30** site. The point **54** at one end **50** of the suture portion **34** is inserted into the tissue such that the point **54** pierces the tissue and the barbs **48** on the portion **58** of the suture body **46** corresponding to the one end **50** yield toward the body **46** to facilitate movement of the suture body as it is drawn through the tissue in the direction of insertion. The point **56** at the other end **52** of the suture portion **34** is also inserted into the tissue and advanced through the tissue in like manner. The tissue is then advanced along the suture portions **58**, **60** within the tissue to close the gap between the tissue and the bone. The barbs **48** of the suture body **46** grasp the surrounding tissue and maintain the tissue in position adjacent to the bone during healing. The leading ends **50**, **52** of the suture body **46** protruding from the tissue are then cut and discarded.

According to the present invention, a surgical procedure using the suture anchor **30** is provided for approximating a torn Achilles tendon to bone for reattachment and healing. It is understood that the applicants do not intend to limit the suture anchor **30** and method of the present invention to only the reattachment of the Achilles tendon.

Referring to FIG. **3**, a human foot **70** is shown with a portion of the outer layer **72** of skin and tissue cutaway to schematically show the Achilles tendon **74** torn away from the heel bone **76**. In this embodiment of the present invention, the user, such as a surgeon, selects a suture anchor **30** (FIG. **4**) having a suture portion **34** of sufficient length and having curved ends **50**, **52** which, in one embodiment, as noted above may be surgical needles. As seen in FIG. **4**, the surgeon begins by inserting the suture anchor **30** into the heel bone **76**. The first and second portions **58**, **60** of the elongated suture portion **34** extend from the anchor portion **32**. Next the surgeon inserts the first end **50** (FIG. **5**), or surgical needle, into the free end of the Achilles tendon **74** and pushes the needle **50** through the tendon **74** along a selected curvilinear path until the point **54** at the first end of the needle **50** extends from an exit point **78** at the periphery of the tendon **74** longitudinally spaced from the end of the tendon. The surgeon grips the needle **50** and pulls the needle out of the tendon **74** for drawing the first portion **58** of the suture body **46** through the tendon **74** leaving a length of the first portion **58** of the suture body **46** in the tendon **74** between the end of the tendon and the exit point **78**, as seen in FIG. **6**. These steps are repeated with the second portion **60** of the suture body **46** beginning with insertion into the end of the tendon **74**.

Methods according to the present invention useful in binding together partially or completely severed tendons, or other internal tissue repairs requiring considerable tensile strength, are suitable for use in attaching tissue to bone. One such method for joining two ends **82**, **84** of a tendon **80** is shown in FIGS. **7-10**. Referring to FIG. **7**, the surgeon begins by inserting a first end **92** of a two-way barbed suture **90**, which may comprise a straight or curved surgical needle, into one end **82** of the tendon **80** and pushing the needle **92** through the tendon **80** along a selected curvilinear path until the point **94** of the needle **92** extends from an exit point **96** in the periphery of the tendon **80** longitudinally spaced from the one end **82** of the tendon **80**. The first needle **92** is gripped and pulled out of the tendon **80** for drawing a first portion **98** of the suture **90** through the tendon **80** leaving a length of the first portion **98** of the suture **90** in the tendon end **82** between the end of the tendon **80** and the exit point **96**. As seen in FIG. **7**, these steps are repeated with a second portion **100** of the suture **90** at the other end **84** of the tendon **80**, wherein a second end **93** of the suture **90** is inserted into the tendon end **84** and advanced along a selected curvilinear path to an exit point **97** longitudinally spaced from the end **84** of the tendon **80**. The second end **93** of the suture **90** projecting from the exit point **97** is gripped and pulled out of the tendon **80** for drawing the second portion **100** of the suture **90** through the tendon **80** and leaving a length of the second portion **100** of the suture **90** in the tendon end **84** (FIG. **8**).

Referring now to FIG. **8**, a second suture **90***a* is introduced into the ends **82**, **84** of the tendon **80**. The first needle **92***a* of the second suture **90***a* is inserted into the one end **82** of the tendon **80** and pushed through the tendon along a selected curvilinear path until the needle **92***a* extends from an exit point **96***a* in the periphery of the tendon **82** substantially co-located with the first exit point **96** of the first portion **98** of the first suture **90**. These steps are repeated with the second portion **100***a* of the second suture **90***a* at the other end **84** of the tendon **80** such that the exit point **97***a* in the periphery of the end of the tendon **84** is substantially co-located with the first exit point **97** of the second portion **100** of the first suture **90**. The needles **92***a*, **93***a* of the second suture **90***a* are pulled out of the tendon **80** for drawing the first and second portions **98***a*, **100***a*, respectively, of the second suture **90***a* through the tendon **80** leaving a length of the second suture **90***a* in the tendon **80** between the exit points **96***a*, **97***a*.

As shown in FIG. **9**, the surgeon reinserts the first needle **92** of the first suture **90** into the periphery of the one end **82** of the tendon **80** at an entry point **102** immediately adjacent the exit point **96** and pushes the needle **92** along a selected curvilinear path until the point **94** of the needle **92** exits the same side of the tendon **82** at an exit point **104** that is longitudinally spaced from the entry point **102**. It is understood that the surgeon could use the exit point **96** as the entry point **102** for the needle **92** if desired. The surgeon pulls the needle **92** out of the tendon **82** for drawing the first portion **98** of the suture **90** through the tendon **82**. The surgeon may then reinsert the needle **92** into the tendon **82** at an entry point (not shown) immediately adjacent the exit point **104** and push the needle **92** along a selected curvilinear path and out of the same side of the tendon **82** at an exit point (not shown) longitudinally spaced from the previous entry point. It is understood that the surgeon makes as many passes as deemed necessary in a "wave-like" pattern for holding the end **82** of the tendon, or as the length or thickness of the tendon **82** allows, and removes the remaining length of the first portion **98** of the suture **90**.

The surgeon repeats the steps described above with the first portion **98***a* of the second suture **90***a* (FIG. **10**) by reinserting the needle **92***a* into the tendon **82** at an entry point **102***a* adjacent the exit point **96***a*, crossing over the first portion **98** of the first suture **90**, and pushing the needle **92***a* along a selected curvilinear path until the needle **92***a* emerges from an exit point **104***a* in the periphery of the tendon **82** substantially co-located with the second exit point **104** of the first portion **98** of the first suture **90**. In this manner, the surgeon advances longitudinally along the end **82** of the tendon **80** with the first portion **98***a* of the second suture **90***a* in a "wave-like" pattern which generally mirrors that of the first portion **98** of the first suture **90**.

The previous steps are repeated at the other end **84** of the tendon **80** with the second portions **100**, **100***a* of the first suture **90** and second suture **90***a*. The pattern of the second portions **100**, **100***a* of the sutures **90**, **90***a* in the second end **84** of the tendon **80** generally mirrors that of the first portions **98**, **98***a* of the sutures in the first end **82** of the tendon **80**. Thus, the exit points and entry points of the first and second sutures **90**, **90***a* are substantially co-located.

The ends **82**, **84** of the tendon **80** are brought together by pushing the tendon ends along the sutures while maintaining tension on the free ends **92**, **92***a*, **93**, **93***a* of the sutures **90**, **90***a*. The barbs **48** maintain the sutures **90**, **90***a* in place and resist movement of the tendon ends **82**, **84** away from this position. The needles along with remaining lengths of the suture portions **98**, **98***a*, **100**, **100***a* are cut and discarded.

FIGS. **11-13** show the suture pattern resulting from use of the above-described method of the present invention. It is understood that we do not intend to limit ourselves to the depth or length of the suture paths shown in the FIGs. as the amount of tissue grasped by each pass, which is related to the depth of the suture path into the tissue and the length of the pass from entry point to exit point, may be determined by the surgeon based on a number of factors including the tissue to be joined.

Another method according to the present invention for joining two ends **82**, **84** of a tendon **80** which is suitable for use in attaching tissue to bone is shown in FIGS. **14-17**. Referring to FIG. **14**, the surgeon begins by inserting the first end **92** of a two-way barbed suture **90**, which may comprise a straight or curved surgical needle, into one end **82** of the tendon **80** and pushing the needle **92** through the tendon **82** along a selected curvilinear path until the point **94** of the needle **92** extends from an exit point **96** in the periphery of the tendon **82** longitudinally spaced from the one end **82** of the tendon. The first needle **92** is gripped and pulled out of the tendon **82** for drawing the first portion **98** of the suture **90** through the tendon **80** leaving a length of the first portion **98** of the suture in the tendon **80** between the tendon end **82** and the exit point **96**. As seen in FIG. **14**, these steps are repeated with the second portion **100** of the suture **90** at the other end **84** of the tendon **80**. That is, a second end **93** of the suture **90** is inserted into the tendon end **84** and advanced along a selected curvilinear path to an exit point **97** longitudinally spaced from the end **84** of the tendon **80**. The exit point **97** of the second needle **93** is on the opposite side of the tendon **80** from the first exit point **96** of the first portion **98** of the suture **90**. The second end **93** of the suture **90** projecting from the exit point **97** is gripped and pulled out of the tendon **80** for drawing the second portion **100** of the suture **90** through the tendon **80** and leaving a length of the second portion **100** of the suture **90** in the tendon end **84** (FIG. **15**).

Referring now to FIG. **15**, a second suture **90***a* is introduced into the ends **82**, **84** of the tendon **80**. The first needle **92***a* of the second suture **90***a* is inserted into the end **82** of the tendon **80** and pushed through the tendon along a selected curvilinear path until the needle **92***a* extends from an exit point **96***a* in the periphery of the tendon **82** substantially co-located with the first exit point **96** of the first portion **98** of the first suture **90**. These steps are repeated with the second portion **100***a* of the second suture **90***a* at the other end **84** of the tendon **80** such that the exit point **97***a* in the periphery of the end of the tendon **84** is substantially co-located with the first exit point **97** of the second portion **100** of the first suture **90**. The needles **92***a*, **93***a* of the second suture **90***a* are pulled out of the tendon **80** for drawing the first portion **98***a* and second portion **100***a* of the second suture **90***a* through the tendon **80** leaving a length of the second suture **90***a* in the tendon **80** between the exit points **96***a*, **97***a*.

As shown in FIG. **16**, the surgeon reinserts the second needle **92***a* into the periphery of the one end **82** of the tendon **80** at an entry point **102***a* immediately adjacent the exit point **96***a* and pushes the needle **92***a* along a selected curvilinear path until the point **94***a* of the needle **92***a* exits the opposite side of the tendon **82** at an exit point **104***a* that is longitudinally spaced from the entry point **102***a*. It is understood that the surgeon could use the first exit point **96***a* as the entry point **102***a* for the needle **92***a* if desired. The surgeon pulls the

needle **92***a* out of the tendon **82** for drawing the first portion **98***a* of the suture **90***a* through the tendon **82**. The surgeon may then reinsert the needle **92***a* into the tendon **82** at an entry point (not shown) immediately adjacent the exit point **104***a* and push the needle **92***a* along a selected curvilinear path and out of the opposite side of the tendon **82** at an exit point (not shown) longitudinally spaced from the previous entry point. It is understood that the surgeon makes as many passes in a "side-to-side" pattern as deemed necessary for holding the end **82** of the tendon **80**, or as the length or thickness of the tendon end **82** allows, and removes the remaining length of the first portion **98***a* of the second suture **90***a*. With each pass, the longitudinal distance between the entry point and exit point decreases. The surgeon repeats these steps with the second portion **100***a* of the second suture **90***a* at the other **84** of the tendon **80**. The second end **93***a* of the suture **90***a* is inserted into the other end **84** of the tendon **80** at an entry point **106***a* immediately adjacent the first exit point **97***a* and advanced along a selected curvilinear path to an exit point **108***a* opposite and longitudinally spaced from the entry point **106***a*. The second portion **100***a* of the second suture **90***a* is drawn through the tendon **80** leaving a length of the second portion **100***a* of the suture **90***a* in the tendon (FIG. **17**).

The surgeon repeats the steps described above with the first portion **98** and second portion **100** of the first suture **90** at the ends **82**, **84** of the tendon **80**. As seen in FIG. **17**, the needle **92** at the end of the first portion **98** is inserted into the tendon end **82** at an entry point **102** adjacent the exit point **96** and pushed along a selected curvilinear path until the needle **92** emerges from an exit point **104** in the periphery of the tendon **82** substantially co-located with the second exit point **104***a* of the first portion **98***a* of the second suture **90***a*. In this manner, the surgeon advances longitudinally along the end **82** of the tendon **80** with the first portion **98** of the first suture **90** in a "side-to-side" pattern which generally mirrors that of the first portion **98***a* of the second suture **90***a*. Similar steps are taken with the second portion **100** of the first suture **90** in the other end **84** of the tendon **80**. The pattern of the first suture **90** and second suture **90***a*, as well as the respective first portions **98**, **98***a* and second portions **100**, **100***a* of the sutures **90**, **90***a*, generally mirror one another. The exit points and entry points of the sutures are substantially co-located. The ends **82**, **84** of the tendon **80** are brought together by pushing the tendon ends along the sutures while maintaining tension on the free ends of the sutures **90**, **90***a*. The barbs **48** maintain the sutures **90**, **90***a* in place and resist movement of the tendon ends **82**, **84** away from this position. The needles, along with remaining lengths of the sutures, are cut and discarded. FIGS. **18** and **19** show the suture pattern using the above-described method of the present invention.

It is understood that more sutures may be used in any of the methods of the present invention. The number of sutures used depends on the size, caliber, and length of the tendon to be repaired. Large tendons will require more than two sutures whereas one may suffice for very small tendons. Tendon repair with two sutures according to the present invention exhibits equivalent or better holding power than conventional techniques. Moreover, tendons repaired according to the methods of the present invention maintain their original configuration, profile, contour, and form better when subject to stretching forces. Other methods of tendon repair suitable for use according to the present invention are shown and described in U.S. patent application Ser. No. 09/896,455, entitled "Suture Method", which was filed on Jun. 29, 2001, the contents of which are hereby incorporated by reference.

FIGS. **20** and **21** are two views of the Achilles tendon **74** reattached to the heel bone **76** to promote healing according to the present invention using the suture method shown in FIGS. **7-13**. The tendon **74** and bone **76** will, over time, grow together.

The present invention provides a compact and easy to use suture anchor and method for reattaching tissue, such as tendons and ligaments, to bone or other connective tissue. The curvilinear placement paths of the suture portion, as contrasted with linear insertion, provide substantially increased biomechanical strength for approximating tissue and bone, or the ends of tendon. The barbed suture portion permits tissue to be approximated and held snug during suturing with less slippage of the suture in the wound. The barbs spread out the holding forces evenly thereby significantly reducing tissue distortion. The suture anchor is useful in endoscopic and arthroscopic procedures and microsurgery. Since knots do not have to be tied, arthroscopic knot tying instruments are unnecessary. If there is an accidental breakage of the barbed suture, the wound is minimally disturbed whereas, with conventional sutures, dehiscence would occur.

Although the present invention has been shown and described in considerable detail with respect to only a few exemplary embodiments thereof, it should be understood by those skilled in the art that we do not intend to limit the invention to the embodiments since various modifications, omissions and additions may be made to the disclosed embodiments without materially departing from the novel teachings and advantages of the invention, particularly in light of the foregoing teachings. For example, the methods of the present invention can be used with a suture anchor alone as a two-way barbed suture. Accordingly, we intend to cover all such modifications, omissions, additions and equivalents as may be included within the spirit and scope of the invention as defined by the following claims.

What is claimed is:

1. A suture system comprising:

a suture system adapted for positioning in tissue and to remain in said tissue after said positioning, the suture system comprising:

a plurality of sutures, each suture having a first end and a second end;

a plurality of barbs located on each suture of the plurality of sutures between the first end and the second end;

each of the barbs of each of the plurality of barbs oriented so as to permit movement of each said suture in a first direction through tissue and to prevent movement of the suture in an opposite direction;

a body located between the first ends and the second ends of said plurality of sutures; and

said body connecting together said sutures of said plurality of sutures; and

said body is slidably located on said sutures; and

said body has an opening and said sutures can move relative to said opening.

2. The system of claim **1** wherein:

said body has said opening and another opening and said sutures can slide through both said opening and said another opening.

3. The system of claim **1** wherein:

said body is cylindrical.

4. The system of claim **1** wherein:

said body includes a bio-absorbable material.

5. The system of claim **1** wherein:

said body includes at least one of ridges, barbs and serrations.

6. The system of claim **1** wherein:

said body includes an opening and said sutures can slide relative to said opening.

7. The system of claim **1** wherein:

said body is cone shaped.

8. The system of claim **1** wherein:

said body is wider than any of said sutures.

9. The system of claim **1** wherein:

said body includes an outer surface that can engage and hold tissue.

10. The system of claim **1** wherein:

said body has an outer surface that can hold tissue.

11. The system of claim **1** wherein:

said sutures are provided through said opening, and said body is located around said sutures.

12. A system comprising the system of claim **1** wherein:

a needle is attached to each of said first end and said second end of each suture.

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